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May 24, 1927

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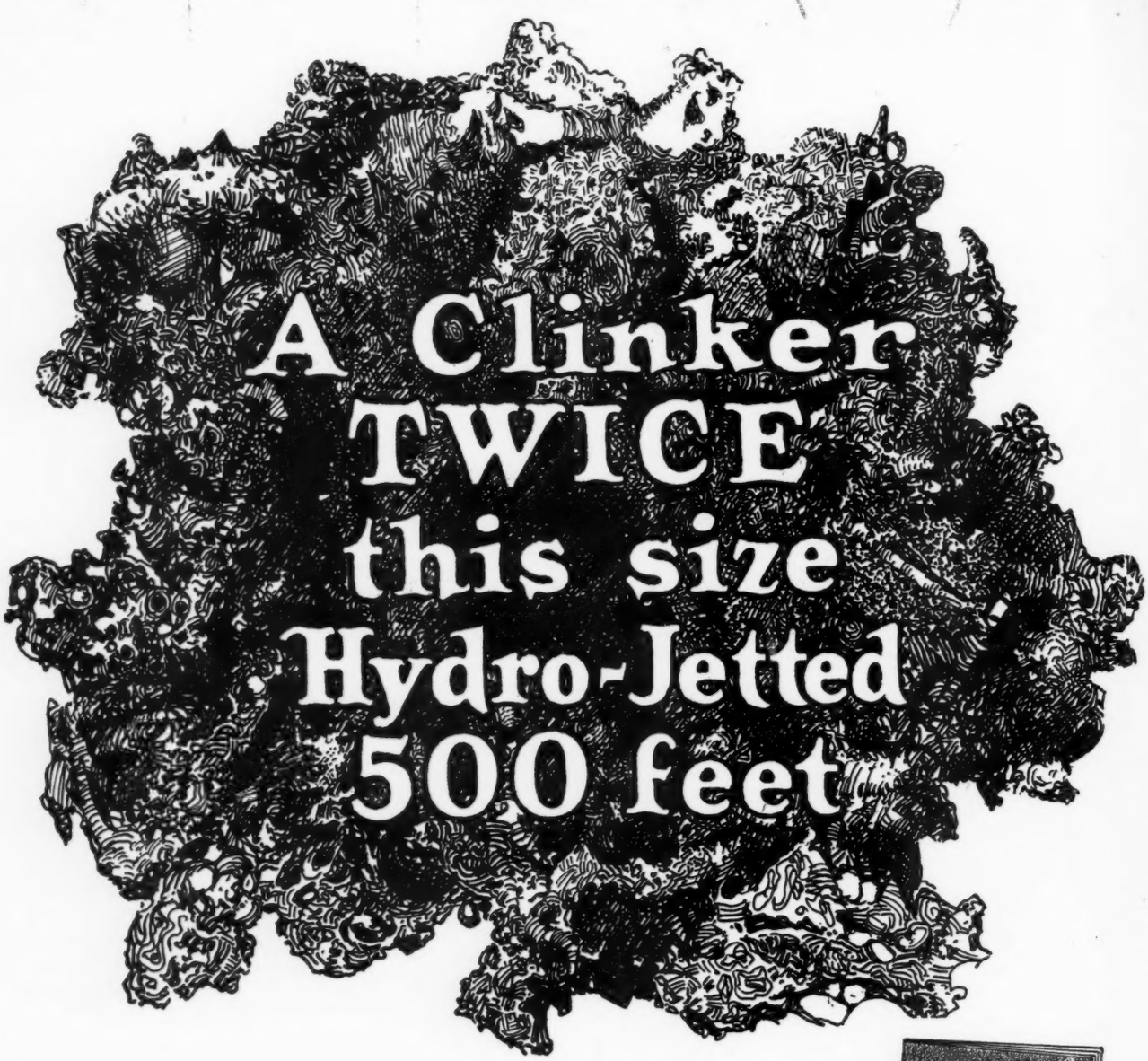

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Nothing Moves but the Ashes

Volume 65 May 24, 1927 Number 21

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POWER

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POWER

Volume 65 New York, May 24, 1927 Number 21

Community Blotches

IN A NICE residential block in the suburbs there is an empty plot.

The houses upon the block, although not sumptuous, are owned and used by people who have a pride in their homes and their surroundings and sufficient diligence, time or means to keep them presentable.

The houses, set well back from the broad flagged and shaded walk, are separated by stretches of lawn and surrounded by shrubbery and flowers. Each is a delight not only to its occupant, but to his neighbors and to all who pass that way.

There is a well-to-do air, an air of interested upkeep about it—all but the empty lot.

There, confusion runs riot. The withered stalks of last season's crop of weeds contribute their clutter to the picture and offer their support to the creeping vegetation of the present spring. It is a dumping place for those who live too far away to be annoyed by it, a trap for wind-swept rubbish of all sorts, a repository for the wash boilers, kettles and other concomitants of juvenile distraction. In winter, foot passengers wade and flounder over its unshoveled sidewalk. Unattended females hug the curb side of the walk and hurry by it after dark; and all the season long the seeds of the dock and plantain and other weeds that it produces with the lavishness of Nature uncontrolled, are scattered through the neighboring lawns and gardens.

I suppose the owner of that lot would be grossly insulted if he were told that he was a public nuisance.

I don't suppose there is any way that he could be compelled to put that piece of property more nearly into conformity with its surroundings.

Any more than there is any way to compel those repugnant personalities who desecrate a circle, a society, an industry by violating the amenities that cultured people practice, and scatter by their influence and example the seeds of the tolerance and practice of evil.

It is back-breaking, knee-wearing work to dig weeds—botanical or moral.

Finding *and* Curing Corrosion*

By C. E. JOOS†

THE author, who has made a thorough study of the subject, tells how to go about finding out what is causing corrosion and where the trouble begins, and then he tells how to cure it. Some of his suggestions have not been tried before, and this original presentation of actual test results should prove helpful to the engineer who is troubled with corrosion.

CORROSION of iron pipes, boilers, economizers and steam lines and the "red-water" trouble in hot-water piping systems have always been the cause of serious annoyance and great expense. Now, with increasing use of water-purifying equipment, such as softeners, evaporators, etc., corrosion is intensified and occurs in many places formerly free from it. The reason is that when scale-forming matter has been removed from the water, nothing remains to prevent attacks upon the iron by dissolved gases. The selection of water-treating equipment should therefore be made with care, taking into consideration not only the nature of the water to be purified, but also the type of plant in which it is to be used.

Where pure or soft water is used as boiler feed, the essential cause of corrosion is dissolved oxygen, the action of which may be aggravated by the presence of free carbon dioxide. Low feed-water temperature or improper venting of the heater is usually associated with high oxygen content of boiler feed water. Fig. 1 shows a typical example of corrosion due to aërated feed water. It shows corrosion that took place at various points throughout the feed-water system of a new central station. Because of its general significance this case will be discussed somewhat in detail.

The plant from which the samples were taken uses a surface water that has been coagulated, settled, filtered and treated. The exhaust steam is condensed in a surface condenser and the boiler-feed makeup required is approximately 10 per cent. Table I gives an average analysis of the raw water.

TABLE I—AVERAGE ANALYSIS OF RAW WATER, GRAINS PER GALLON

Silica	0.7	Sodium chloride	1.3
Iron and alumina	0.3	Sodium sulphate	2.3
Calcium carbonate	3.5		
Calcium sulphate	5.7	Total solids	14.4

Shortly after this plant was put into operation corrosion was indicated by the appearance of rusty precipitate in the boiler water. An analysis of this sediment gave the results shown in Table II.

The suspicion that corrosion was taking place was verified by placing carefully prepared samples of boiler-

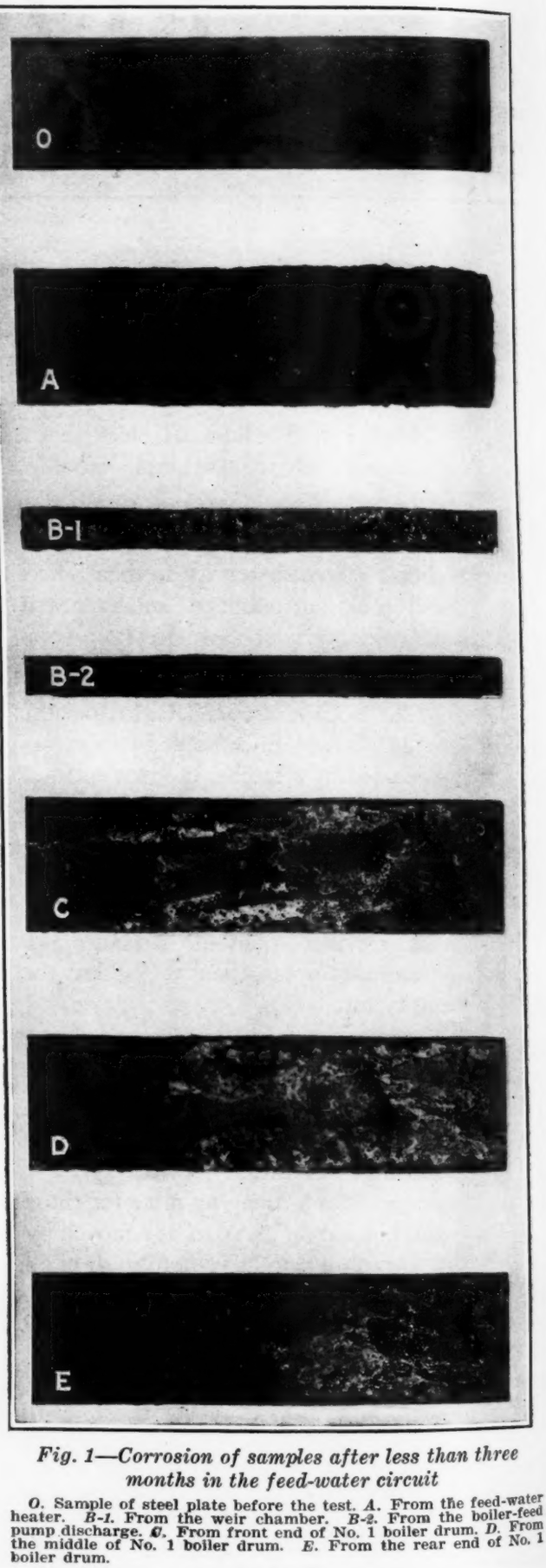

Fig. 1—Corrosion of samples after less than three months in the feed-water circuit

O. Sample of steel plate before the test. *A.* From the feed-water heater. *B-1.* From the weir chamber. *B-2.* From the boiler-feed pump discharge. *C.* From front end of No. 1 boiler drum. *D.* From the middle of No. 1 boiler drum. *E.* From the rear end of No. 1 boiler drum.

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tube metal at representative locations in the feed-water system. These strips were cleansed with dilute sulphuric acid, neutralized with sodium carbonate, washed with water and dried with alcohol. They were suspended by iron wire to eliminate any possibility of corrosion by galvanic action. The samples were in position for a period of less than three months, with the average plant conditions given in Table III.

The condition of the strips after removal for the several locations may be seen in Fig. 1. The results of

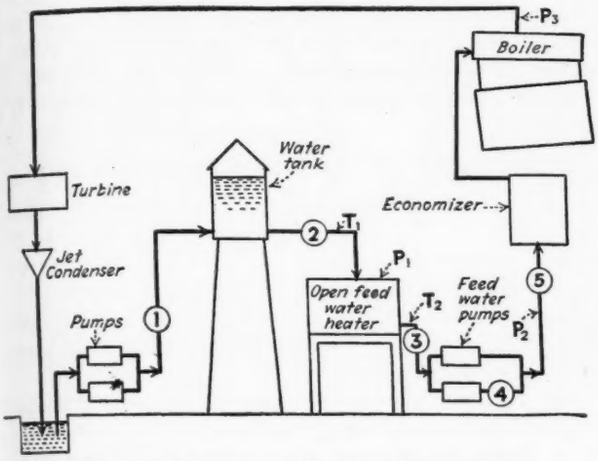


Fig. 2—Diagram of feed-water circuit

Numbers in circles indicate points where oxygen determinations were made. *T* and *P* designate location of temperature and pressure readings.

analyses of the incrustations on the several samples, given in Table IV, leave no doubt that corrosion was taking place. It is evident that the combination of low feed-water temperature and the type of softener used in this plant results in corrosion in all parts of the plant. The softening equipment must be considered in connection with the conditions under which it is to operate.

Advantages of Making an Oxygen Survey Where There Is Corrosion

In any instance of corrosion, such as that cited, snap judgment should not be made or apparatus condemned until facts are available to prove beyond doubt the source of the trouble. There should be thorough tests representing typical conditions. Data should be collected over the entire system simultaneously, so that the operation of each unit and the part it may play in causing corrosion can be checked. The character of the plant survey will depend upon the actual conditions. A typical example from actual experience will illustrate the advantages to be gained from such a survey.

TABLE II—ANALYSIS OF SEDIMENT FROM

	Boiler Tube and Mud Drum, Per Cent	Steam Drum at Water Line Per Cent
Silica	12.28	7.40
Iron and alumina	64.46	82.08
Calcium sulphate	none	none
Carbonates of lime and magnesium	23.26	10.52

TABLE III—CONDITIONS DURING CORROSION TEST

Temperature of feed water, deg. F	194
Alkalinity of boiler water, grains per gal	29.1
Oxygen in feed water, c.c. per liter	1.17
Sodium carbonate in make up water, grains per gal	8.95
Conversion of carbonate to caustic in boiler water, per cent	82.1
CO_2 liberated within boiler per gal. make-up water, grains	7.5

A large industrial plant using raw river water as the entire boiler feed was troubled with corrosion in steel-tube economizers. While the feed water contained a little scale-forming material, there were no free or potential acids, such as magnesium chloride or sulphate, which would cause corrosion. That corrosion was due to electrolysis was improbable, since it was always confined to the economizers and appeared with equal intensity in each of the units. Oxygen corrosion therefore appeared to be the most likely, and a survey was made to determine this kind of corrosion.

Fig. 2 shows the layout of the equipment and the points at which readings were taken. The survey lasted seven hours, giving an average of normal operating

TABLE IV—ANALYSIS OF INCRUSTATION ON SAMPLES OF BOILER TUBE METAL

Location of Sample	Ferrous Oxide Per Cent	Ferric Oxide Per Cent
Feed-water heater	26.7	65.2
Weir chamber of meter	26.9	67.3
Water-pump discharge	24.7	66.1
Front end of boiler drum	15.6	74.6
Middle of boiler drum	29.6	44.4
Rear end of boiler drum	19.0	73.6

TABLE V—TEST OF POTASSIUM BICHROMATE AS INHIBITOR OF CORROSION

Water	Grs. per Gal. Chromate	Weight of Test Pieces, Grams Before Test	After Test	Difference	Relative Corrosion, Per Cent
Distilled	0.0	19.36615	19.2235	0.0438	100
Treated	0.0	17.91755	17.86715	0.0504	124
Treated	0.9525	19.36890	19.35600	0.0129	29.4
Treated	1.8720	18.73540	18.72525	0.0105	24.7
Treated	1.8720	18.62540	18.71500	0.0104	24.65
Treated	1.8720	18.44775	18.44195	0.0058	13.9

conditions. The results plotted in Fig. 3 indicate that the raw water entering the plant is just about saturated with oxygen. A comparison of Station 3 with Station 2 shows the degree to which oxygen is removed in the heater. The amount remaining in the water leaving

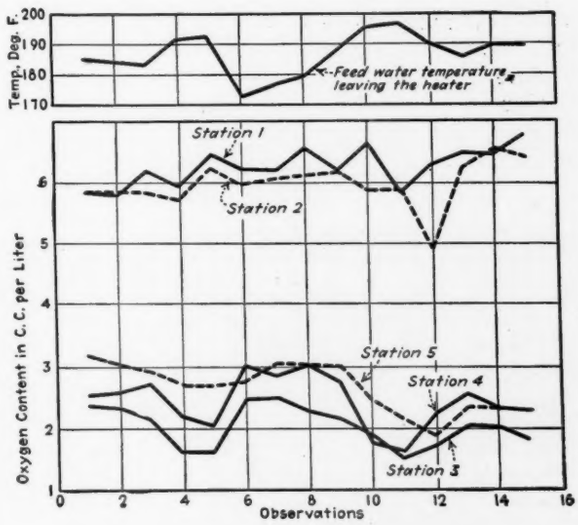


Fig. 3—Variation in water temperature and oxygen content

the heater, at Station 4, is sufficient to cause corrosion and would ordinarily be considered high for boiler feed water. The reason for this high oxygen content is that the feed-water temperatures are low in relation to the pressure carried within the heater (2 lb. per sq.in. gage), which suggested more liberal venting of the latter in order to bring about higher feed-water temperatures and a consequent lower content of oxygen. A comparison of stations 4 and 5 with 3 indicates that there was infiltration of air through the feed pumps, which are of the outside-packed plunger type. Stations 4 and 5 do not agree, owing to the fact that Station 5

represents the total feed water, while Station 4 represents only that supplied by one pump, the infiltration of air through the pumps being different.

The conclusions that can be drawn from such a survey not only establish and locate the cause of corrosion, but they also suggest the remedies that should be applied. Had it not been for the survey, it is doubtful whether the infiltration through the boiler feed pumps would have been discovered. The maintenance of high feed-water temperatures was only part of the solution, which shows the necessity of gathering sufficient facts before condemning this or that piece of apparatus.

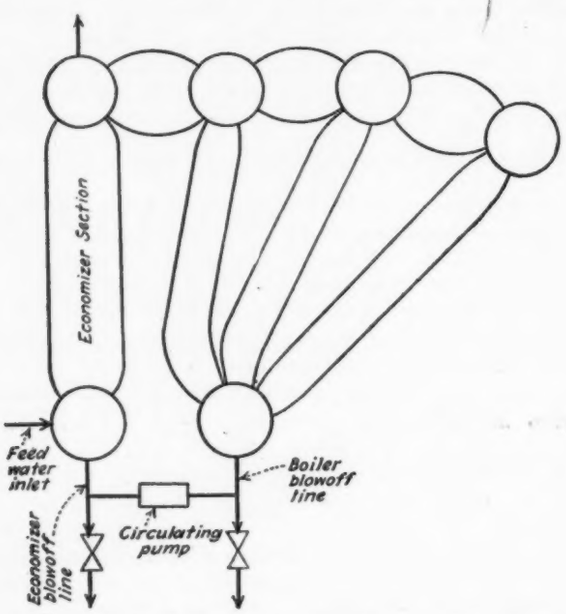


Fig. 4—Arrangement for recirculating water through economizer section of boiler to retard corrosion

From time to time various methods for preventing oxygen corrosion other than deaëration are suggested. These methods are chiefly chemical, and their efficiency depends upon the formation of some sort of protective coating. In this class may be mentioned paints and coatings of various kinds to be applied to the surface when the latter is dry. Other substances, such as silicate of soda, depend upon precipitation for the formation of a protective film. Still other chemical methods that have been suggested depend upon reducing the hydrogen-ion concentration. As a general rule the relief afforded by these means is temporary. Coatings must be replaced and rigid control must be maintained over chemical dosing methods. Experience with one of these methods, as given below, will serve to exemplify this point.

Recirculation To Prevent Oxygen Corrosion

It is well known that oxygen corrosion takes place less rapidly as the hydrogen-ion concentration[1] is decreased. Because of this it has been suggested to use this as a means of preventing oxygen corrosion. To decrease the hydrogen-ion concentration, it is only necessary to introduce caustic soda into the feed water in proper quantities.

With boilers having integral economizers and fed with softened water, the hydrogen-ion concentration can be decreased by simply recirculating a portion of the highly concentrated boiler water through the economizer section, by a pump placed between the blowoff lines of the boiler and economizer sections. This arrangement is illustrated in Fig. 4. As an experiment this method of preventing oxygen corrosion was tried over a period of ten days. Prior to placing the boiler on the line, an initial charge of soda ash was placed in one of the boiler drums in order to insure a higher

[1]Hydrogen-ion concentration is a chemical measure of the effective acidity of a solution. Lower hydrogen-ion concentration means less acidity.—Editor.

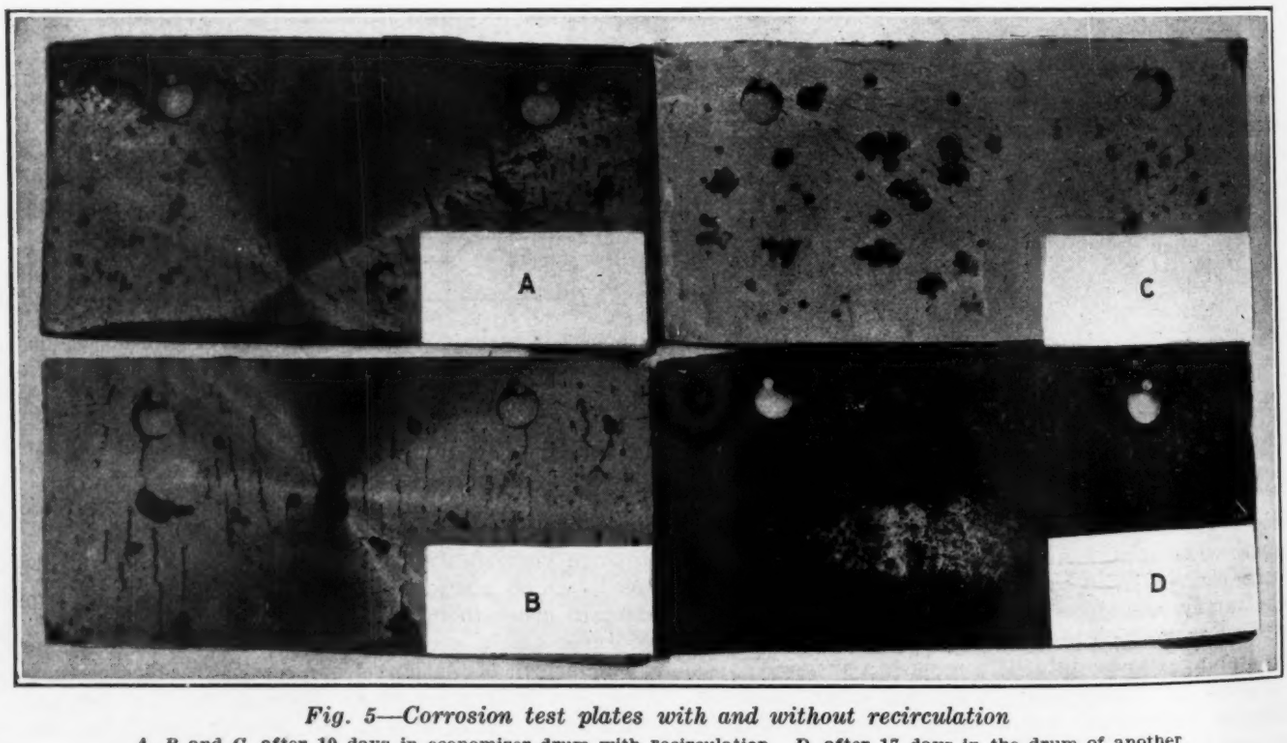


Fig. 5—Corrosion test plates with and without recirculation

A, B and *C*, after 10 days in economizer drum with recirculation. *D*, after 17 days in the drum of another economizer without recirculation.

alkalinity at the very start. Three samples of flange steel ground to a polish were suspended in the economizer drum by an iron wire.

Before the boiler was connected to the line, recirculation was started and continued the entire ten days. The amount of concentrated boiler water recirculated

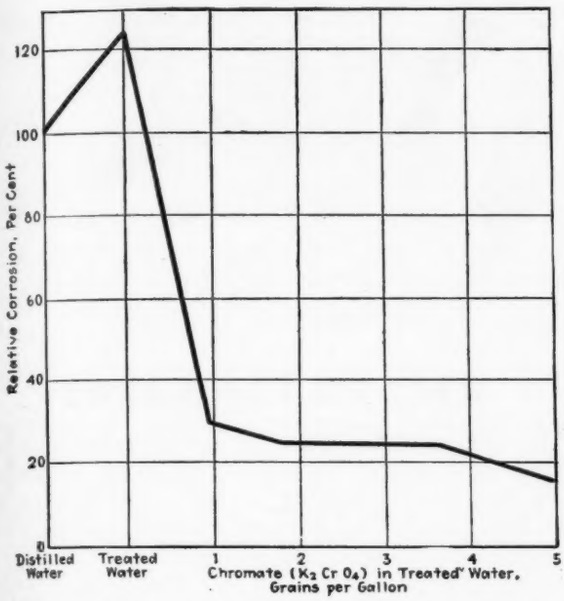


Fig. 6—Effect of chromates in reducing corrosion

through the economizer section was calculated from the speed and displacement of the pump, neglecting slippage. On this basis the concentrated boiler water was circulated to the extent of 12.8 per cent of the feed water, producing an average alkalinity within the economizer section of approximately 20 grains per gal., calculated in terms of sodium carbonate, including the alkalinity of the feed water. On the basis of 75 per cent conversion of carbonate to caustic, the actual concentration of sodium hydrate within the economizer section was approximately 10 grains per gal. The oxygen content of the feed water was consistently below 0.5 c.c. per liter.

At the completion of the test the plates were removed immediately after draining the boiler, washed in alcohol and dried carefully to prevent oxidation. The installation and removal of the plates was executed in such a manner as to prevent any corrosion other than that occurring during boiler operation. The results of this test are clearly shown by Fig. 5, in which for comparison is included a plate placed for 17 days in an economizer drum that did not have recirculation. The condition of the drums was comparable to that of the test plates shown.

While it is evident that this method of treatment materially reduced the corrosion taking place normally, it did not arrest oxygen corrosion altogether. As the concentration of boiler water within the economizer section was high (20 grains) and the oxygen low in this experiment, it is doubtful whether this method could be made of any practical value if complete protection against oxygen corrosion under every condition is desired. To recirculate larger quantities of boiler water through the economizer section would reduce its efficiency, as the recirculating water introduced into the economizer section at boiler temperature would materially raise the temperature of the economizer and thereby reduce the absorption of heat from the flue gases.

Use of Soluble Chromates to Prevent Corrosion

J. Newton Friend, in his book on "Corrosion of Iron and Steel," suggests the use of soluble chromates as a means of inhibiting oxygen corrosion. The manner in which chromates act in this respect is not clearly established, but their inhibiting action has been known for a long time. In order to determine the efficiency of chromates as a protection against oxygen corrosion, weighed test pieces of polished boiler-tube metal measuring 1 in. square were suspended by means of thin glass rods in treated water containing potassium chromate of concentrations indicated in Table III. The apparatus was assembled on an electric hot plate and the temperature kept at 174 deg. F. A steady stream of air was bubbled through the water to keep it saturated with oxygen. The temperature maintained, 174 deg. F., was the temperature at which under-water corrosion at atmospheric pressure will take place most rapidly, as determined by Friend and other investigators. After 9 hours the air and heat were turned off and the samples were allowed to stand in the various solutions over night. They were then cleaned with a 10 per cent solution of ammonium acetate, dried with alcohol and weighed.

The data of Table V and Fig. 6 show the inhibiting

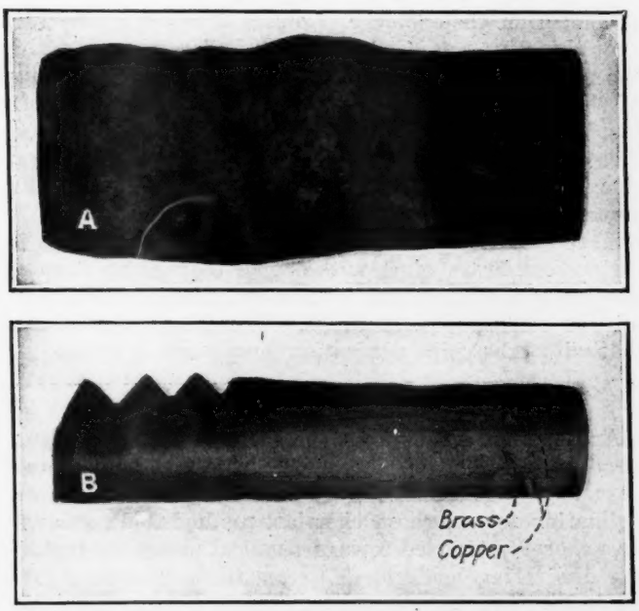


Fig. 7—Brass pipe in contact with oxygen-bearing water fails by dezincification

Corrosion eats the zinc out of the brass, leaving a porous and brittle skeleton of copper.

A. A piece of brass pipe covered with zinc sulphate, formed by reaction of the zinc from the brass and sulphates in the water.

B. Section of brass pipe from an air washer in which water passes through the inside of the tubes, and is then sprayed over the outside. Failure is evident both outside and in.

effect of even small quantities of potassium chromate. The comparison is based on taking the corrosion in distilled water as 100. The fact that as little as one grain per gallon of potassium chromate will reduce the corrosion to almost one-quarter that taking place in distilled water is of special interest. Because of the cost of chromates and the fact that rigid control would be

necessary in the introduction of these salts, the commercial aspects of this method of oxygen corrosion prevention are not as promising as might be thought from the inspection of the data. There are instances, however, where such treatment may be used to decided advantage. For instance, when boilers are filled and standing idle for long periods, considerable corrosion may take place from oxygen entering through a leaky stop valve or the boiler feed valve. Where continual oxygen contamination cannot be avoided, chromates serve a useful purpose in checking corrosion; in fact, their use in this way has proved very successful. In some plants it is standard practice to place several pounds of potassium or sodium bichromate or potassium or sodium chromate in boilers that are cold banked.

Use of Brass Piping

Brass piping is sometimes installed in order to avoid corrosion and red water, and while it is true that brass piping eliminates the red water nuisance, it is not immune to failure. Its disintegration is not corrosion in the ordinary sense as applied to iron piping, but is dezincification. Dezincification takes place in brass piping carrying hot water having an appreciable oxygen content, and it has been found that deaëration of the water supply prevents dezincification. In Fig. 7 are reproduced two photographs of brass pipe, showing an incrustation of zinc oxide at a joint and a cross-section of brass piping showing the method by which this dezincification takes place. In the latter illustration copper only is shown on the inside and outside, owing to the fact that this pipe was used in an air cooler through which the water passed and then was sprayed over the outside of the pipe so that the water was in contact with both inside and outside. The copper remaining after dezincification is brittle and easily broken, and a slight vibration will start a leak at the joints. Failure commonly occurs at the roots of the threads where the pipe is weakest. It is now well established that copper pipe is better than brass, since with copper there is no disintegration of the metal and its life will probably be indefinite as compared with brass. The illustration shows that with brass pipe deaëration is well worth while.

Dëaerators

Any method of using chemicals to prevent oxygen corrosion necessitates close supervision and control, and most engineers do not have the equipment, time or inclination to use these chemical methods. Engineers have therefore turned toward physical means by installing deaërating heaters. This apparatus prevents corrosion by removing the cause; that is, by expelling the last trace of oxygen and other corrosive gases, such as free CO_2. The success of the deaëration heater and its widespread use shows that it satisfactorily prevents gaseous corrosion and at the same time fits in with the most efficient methods of steam-plant operation.

The Underlying Principle involved in determining the proper pipe sizes for water-heating mains, risers and branches is to regulate the size of these pipes so that they will carry the maximum amount of water required of them and absorb by friction and static head, all the pressure at the source and still deliver water at the fixture in sufficient quantity but at a pressure practically equaling zero or slightly above, except that due to velocity of flow through the fixture.

What Do You Know?

THE ten questions following are intended as a self cross-examination of your engineering knowledge. Unlike a court trial, nothing you say can be used against you. After answering, turn to page 781 to find if you are correct, and even if wrong, you can conceal your error by turning to the crowd and smilingly declaring, "I got that one right, too." However, a slip should be taken as an indication that you have forgotten a vital engineering fact.

Ques. 1—Where was the first successful power-plant installation of pulverized-coal equipment made?

Ques. 2—Can overheating of a boiler plate occur when it is below the water level?

Ques. 3—The exhaust of an engine using air instead of steam for the working fluid may frost so badly as to close the exhaust ports. What causes this and how can it be avoided?

Ques. 4—Who was Herbert Ackroyd Stuart?

Ques. 5—Is it possible to purge air from a refrigerating system without losing some ammonia?

Ques. 6—Why is a foot valve necessary with a centrifugal pump?

Ques. 7—Should a steam line slope toward or away from the boiler?

Ques. 8—Is it possible to operate a steam engine without using cylinder oil?

Ques. 9—How is a turbine shaft packed against leakage at the high- and low-pressure ends?

Ques. 10—If one is going to blow down one gage, is it best to first fill the boiler to the top gage? Why?

Transmission of Power by Electrical Conductors is now so efficient that any reductions of losses must necessarily be small. However, better operating service, due to better voltage regulation and fewer fuse burnouts, can be obtained at no increased annual cost by the use of larger conductors than those required by the National Underwriters' Code. Sufficient power is saved even at lower power rates and day operation to warrant some increase in conductor sizes. For day-and-night operation, and especially for higher power rates, still larger sizes are warranted by the power saving.—*George Wrigley in Mechanical Engineering.*

Power Factor Simplified

A SIMPLE explanation of what the power factor of an alternating-current circuit is, how it may be obtained, and how it is used in calculating the power of such circuits

By P. W. SAWYER

THERE are three things in an alternating-current circuit that influence the flow of the current. These are ohmic resistance, inductance, and electrostatic capacity or condenser effect. In the ordinary low- and medium-voltage circuits, in general, only resistance and inductance have to be considered except when the condenser effect is introduced by some means to neutralize the effect of inductance.

The effect of either inductance or capacity alone is to increase the current in the circuit above, a value representative of the power in watts expended in the circuit. For that reason the ammeter reading cannot be used as a measure of the power transmitted unless modified by a factor that has come to be known as the power factor.

Inductance and Capacity

Either inductance or capacity tends to cause the current to be out of step with the voltage. Inductance causes the current to lag the voltage that is to pass through its zero and maximum values at an instant later than the corresponding values of voltage. Capacity, on the other hand, causes the current to lead the voltage or pass through its zero and maximum values at an instant earlier than the voltage. From this it is evident that inductance and capacity have opposite effects in the circuit, and one may be used to neutralize the other, as is frequently done in practice.

Inductance, as was shown in the previous article,[1] prevents the current in a circuit from reaching its normal value instantaneously. That is, if the switch is closed on a direct-current circuit, voltage is applied instantaneously to the connected device, but it will require a certain time for the current to reach normal value. This time varies with the devices on the circuit. If the load consists of lamps that have practically no inductance, then the current reaches full value almost instantaneously. On the other hand, if the load consists of coils on iron cores, the inductance in the circuit will be high and the current will build up slowly. On some large magnets it was found that several seconds were required for the current to reach normal value. This, of course, is an exceptional case, as in general the time

[1]Page 701, May 10 issue.

required for the current to reach full value is a fraction of a second.

On direct-current circuits inductance occurs only when the circuit is opened and closed, or when there is a change of the current's value in the circuit, and is, therefore, in general of little consequence. However, in an alternating-current circuit where the direction of the current is reversed several times per second, the effects may become an important factor in the operation of the system. As an example of the effects of inductance, in the curve, Fig. 1, it is shown that under the conditions represented, about 0.6 sec. was required for the current to reach normal value after the switch was closed. On a 60-cycle alternating-current system the current reverses 120 times per second. In other words, it flows $\frac{1}{120}$, or 0.008, of a sec. in one direction, when it reverses and flows in the opposite direction.

It is evident, then, that if a circuit of characteristics represented by the curve Fig. 1 were connected to a 60-cycle alternating-current system, practically no current would flow, since 0.6 sec. is required for the current to reach normal value. But the 60-cycle alternating voltage changes its direction once every 0.008 sec., so that the current would hardly begin to build up in one direction before the voltage would reverse and prevent further increase in the current. This is just what would happen if direct-current magnet coils were connected to an alternating-current circuit. It would be found that a very small part of the current would flow in them that obtained on a direct-current system of the same voltage.

A Simple Inductance Experiment

A simple experiment can be made on the time required for the current to build up in an inductive circuit with the field coils of a direct-current machine. If the coils are connected to a source of direct current and let remain there for a few seconds, when the switch is opened a severe arc will occur at the switch when the circuit is interrupted. If the switch is closed and opened

quickly, it will be found that there will be practically no spark at the switch, showing that a small current only is flowing. Lengthening the period that the switch is left closed will increase the severity of the arc when the switch is opened, until the time of maximum excitation is reached. It should be kept in mind that opening the field circuit with full exciting current causes dangerous voltages to be generated in these coils, which is likely to result in an insulation failure.

Effects of Inductance

Another effect of inductance in an alternating-current circuit is to cause the current to lag behind the voltage, as previously mentioned. In an alternating-current circuit the voltage rises from zero to a maximum value in one direction and then decreases to zero again, then reverses and passes through a similar set of values in the other direction, as represented by the curve marked volts in Fig. 2. If the only factor affecting the flow of the current in the circuit is resistance, it will rise and fall with the voltage as represented by the curve marked amperes. In a circuit that has inductance, the current will lag behind the voltage and the voltage and current curves will bear some such relation as shown in Fig. 3. In this case the voltage reaches its maximum value at instant *b*, but the current reaches its maximum value at *c*, an instant later than the voltage. As the voltage decreases the current also decreases, but not in proportion to the voltage, since the induced voltage in the circuit tends to keep the current flowing so that when the line voltage is at zero the current in the circuit has a value represented by the distance *e*.

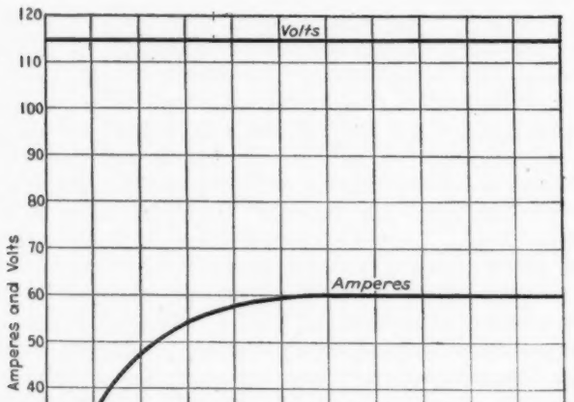
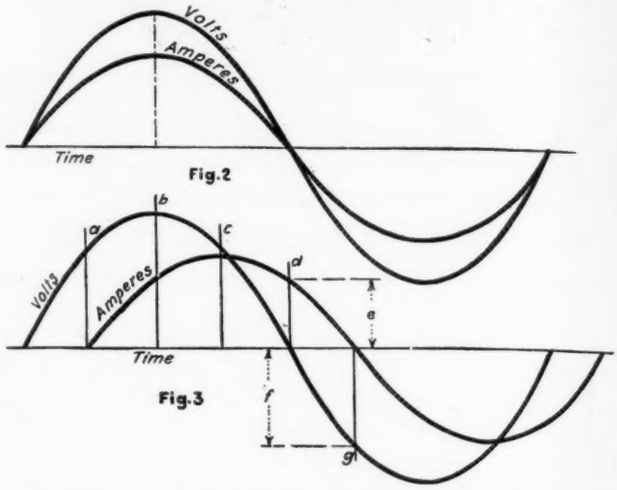


Fig. 1—Curves showing how the current builds up in a circuit

The voltage in the generator has reversed and built up to a value equal to the distance *f* before the current decreases to zero. At this instant the induced voltage in the system and the generator voltage are equal and opposite.

Fig. 4 shows a diagram of a single-phase alternating-current generator connected to a load. Assume that the conditions existing in this circuit are those represented in the curve, Fig. 3. At instant *a* current starts to flow in the circuit in the same direction as the voltage. As the current increases in value, energy is transmitted from the generator to the load. This energy is used up in two ways—part of it in the winding, assuming the load to be a coil, and part stored in the magnetic field. Just as when starting a machine, until the machine is up to speed part of the energy supplied to it is used to



Figs. 2 and 3—Show relation between current and voltage in an alternating-current circuit

overcome the friction of the various parts and part is stored up in the moving mass. At *d* on the curve the voltage of the generator reverses and builds up in the reverse direction, but the current does not reverse until instant *g*. During the period *d* to *g* the conditions in the circuit have reversed and the load has become the generator and the generator the load. That is, the load delivers energy back to the generator to drive it as a motor.

Hydraulic Analogy of Inductance

A hydraulic analogy of this condition is shown in Fig. 5. This system consists of a centrifugal pump and a water motor with a heavy flywheel, the motor and pump being connected with pipes and the whole system filled with water. If the pump is started and brought up to speed, pressure will be built up in the discharge line which will tend to cause the water to flow through the motor and bring it up to speed. On account of the flywheel the motor will be prevented from coming up to speed as quickly as the pump. The energy transmitted from the pump to the motor is used in two ways. Part of it is expended in overcoming the friction of the motor and another part is used to accelerate the pump impeller and the flywheel, and is stored in them by virtue of their motion. This is similar to the electric system, where part of the energy was expended in the load and part stored in the system, the latter by virtue of the magnetic field.

After the pump and flywheel have been brought up to speed, if the power is cut off from the pump, the water motor will continue to run until the energy stored in the flywheel has been expended. The flywheel driving the water motor converts it into a pump and keeps the water circulating in the system and drives what was originally the pump as a water motor, which in turn would drive the electric motor as a generator. This is

similar to the condition in the electric circuit represented on the curves, Fig. 3, by the period from *d* to *g*, when the induced voltage in the load is greater than the voltage of the generator and the former delivers power to the latter to drive it as a motor. One alternation of the pump may have required two or three minutes, while the alternation in the electric circuit, on a 60-cycle system, requires only 0.008 sec.; nevertheless, what took place in both cases is practically the same.

If an ammeter were connected into the alternating-current circuit, Fig. 4, it would not only indicate the current that the generator supplies to the load, but that supplied by the load to the generator. This current is not only a measure of the power delivered by the generator to the load, but also of the power supplied to the generator by the load. Consequently, the ammeter reading is too high to be used as a measure of the energy supplied by the generator, which is the thing desired in most power measurements.

In the hydraulic system, Fig. 5, a flow meter in the

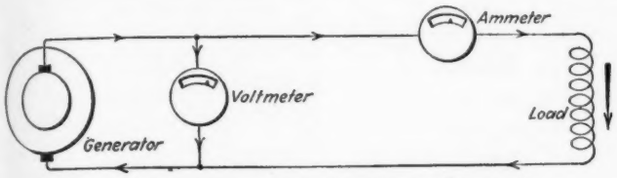


Fig. 4—Diagram of single-phase alternator connected to a load

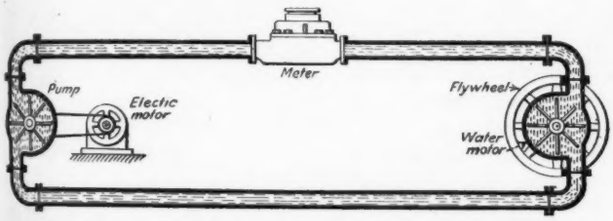


Fig. 5—Hydraulic analogy of the circuit Fig. 4

pipe line would register not only the water passed through the water motor by the pump, but also that passed through the pump by the water motor. If the meter reading were used as one of the factors in obtaining the power supplied by the pump to the motor, it would give a result that is too high. In the same way, in the alternating-current circuit, if the ammeter reading is used as one of the factors to obtain the power delivered by the generator to the load, it will give a value that is too high.

For a direct-current circuit the power in watts equals the product of the volts and amperes. That is, if the voltmeter reading were 240 and the ammeter reading 75, then the watts would equal 240 $\times$ 75, or 18,000, or 18 kilowatts. This value is what a properly calibrated wattmeter would read if connected into the system.

As has already been shown, the ammeter reading when the voltage and current are out of step, is too high to give a measure of the watts in an alternating-current circuit. For this reason the product of the volts and the amperes in an alternating-current circuit has been given the name volt-amperes or kilovolt-amperes. This value alone may mean almost anything respecting the amount of power. If the current were in step with the voltage, as would be practically the case with a load of incandescent lamps, volt-amperes would equal the power in watts. In a circuit where the inductance of the load is high, the value of the watts would be small compared to the value of the volt-amperes. To obtain the watts the volt-amperes are multiplied by a value called the power factor. The power factor is obtained from a meter as shown in the headpiece, and bears a relation to the amount that the current is out of step with the voltage, as will be shown in a later article. If the current is in step with the voltage, the power factor is unity, or 1. This is just as it should be, since the volt-amperes, under this condition, multiplied by one, gives a value for watts equal to volt-amperes. When the current and voltage are out of step, the power factor is less than unity, such as 0.80 or 0.65.

Assume that in a single-phase alternating-current circuit the voltmeter reading was 460, the ammeter reading 65, and the power factor meter 0.80. Then the volt-amperes would equal volts times amperes, equals 460 $\times$ 65 = 29,900, or 29.9 kilovolt-amperes, or as it is generally referred to, kva. The watts equals volt-amperes times the power factor. In this problem this would be 29,900 $\times$ 0.80 = 23,920 watts, or 23.92 kilowatts, the wattmeter reading. Where the wattmeter reading is available with the voltmeter and ammeter readings, the power factor may be calculated from these values; that is, power factor equals watts divided by volts times amperes. Using the values in the preceding problem, the power factor equals 23,920 $\div$ 460 $\times$ 65 = 0.80. In a balanced two-phase circuit the volt-amperes is obtained by multiplying the voltmeter and ampere readings of one phase by two and in a three-phase circuit by 1.732.

A wattmeter connected in an alternating-current circuit will indicate the watts and not the volt-amperes. This and other features will be made the subject of another article.

Effects of Drying-Out Processes on Winding Insulation

Drying out motor windings by passing an electric current through them is frequently suggested and applied. This method is sometimes used in connection with drying in an oven. Such a practice accelerates the drying-out process and reduces the time required to get the winding in condition to go back into service. A feature of this practice that is generally overlooked, is the effect of current leaks between turns of the windings. Such leaks cause an electrolytic action between the conductors, which has a tendency to leave a copper-salt deposit in the insulation.

Cases are on record where motors were submerged while running and ran until they were short-circuited and blew the fuses. When these machines were dried out in an oven, the insulation on the windings became green in color and was in such poor condition that new windings were required on all machines that were running when submerged. Other machines that were disconnected from the line before being submerged were easily dried out and their insulation restored to apparently normal condition. The windings on these machines were not impregnated with insulating compound, as is the general practice today. However, this experience shows that it is possible to destroy the insulation on the windings permanently by allowing a current to flow through the conductors after being submerged in water, at least where the insulation is not thoroughly impregnated with insulating compound.

The Air Lift Pump

Made Simple

How It Works
Good and Bad Points

By WM. V. FITZGERALD

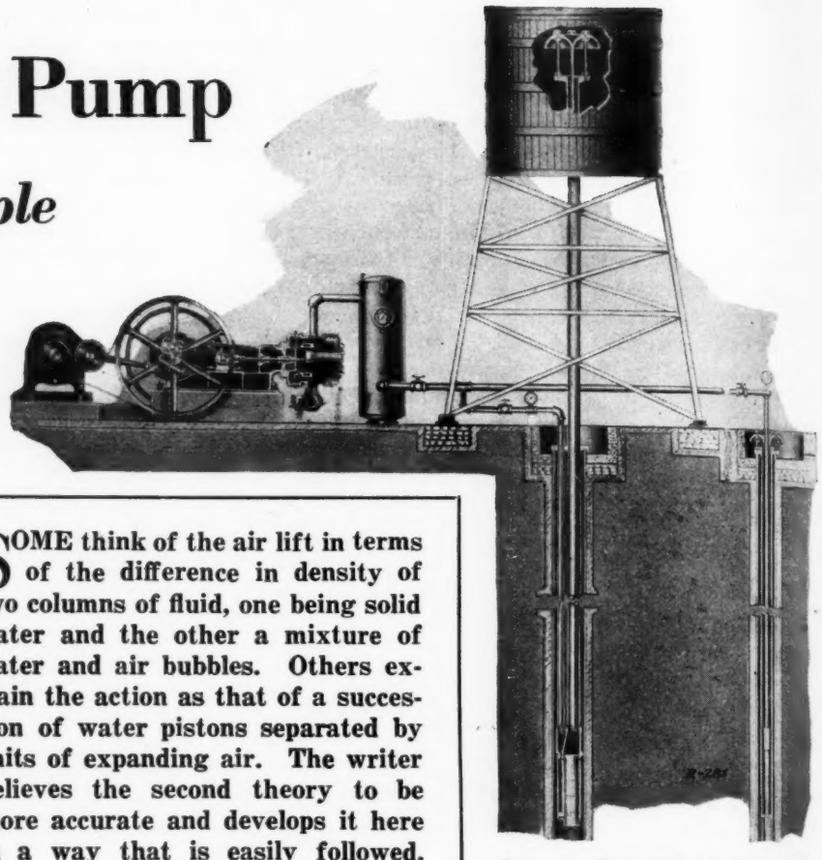


Fig. 1—Complete air-lift outfit
Courtesy Ingersoll-Rand Co.

SOME think of the air lift in terms of the difference in density of two columns of fluid, one being solid water and the other a mixture of water and air bubbles. Others explain the action as that of a succession of water pistons separated by units of expanding air. The writer believes the second theory to be more accurate and develops it here in a way that is easily followed.

THE use of compressed air is old, dating back to 1797. Since 1888 the air-lift pump has been in common use, although during the intervening years, little that is new has been learned in this particular field. Development has been along the lines of perfecting air-compressor equipment and improving the methods of introducing the air to the pump.

Apart from the production of compressed air there is little more to the apparatus involved than a large delivery pipe, near the bottom of which a pipe introduces air through a device that breaks the air up into many small bubbles.

However, the theory of the air-lift pump is often not clearly understood and would bear a more or less detailed description of the principles involved and of the general arrangement of the parts.

One theory is that the motive power operating the pump is the difference in specific gravity between the water outside the pump and the mixture of air and water within the pump or discharge pipe. While it is difficult to dispute this theory, it is, nevertheless, difficult to see the pumping action purely as a result of a difference in specific gravity between the two columns. However, a difference of this kind would cause a flow of water.

Another theory is that each bubble displaces an equal volume of water in the discharge pipe and therefore raises the level of water in the pipe.

On first sight it might seem that there is really very little difference in the two theories. On second thought there seems to be a difference, as will be brought out a little later.

It might be well to disregard, for the moment, the statements made on the theory and to start with the simplest form of air-lift pump possible. For example, in Fig. 2 at *A* let us suppose that x represents a water piston inclosed in a long tube y, closed at the bottom, and suppose that air is introduced into the tube at its lower end by pipe z. Assuming the piston to work in the tube without friction, let us suppose that a definite volume of compressed air is admitted to the tube while the piston x is near the bottom. Immediately (the bottom end of the tube being closed) the compressed air seeks to expand and the piston rises in the tube until it reaches a point at which its weight balances the air pressure in the tube. This, in an elementary way, is what happens in the air-lift pump.

Going farther, as at *B*, Fig. 2, consider a number of these frictionless pistons, each one having the same weight and separated at the bottom of the long tube by the same weight of air. Immediately, the whole group of pistons begins to rise and continues to rise until a state of equilibrium is reached. Assume this state to be as shown in the diagram.

The air in the space a has the least pressure upon it, therefore it occupies a greater space than that at b, which is compressed by the weight of two pistons. This condition holds true for all spaces until the lowest space is reached. Here the air is considerably compressed owing to the weight of all the pistons upon it.

This, also, is what happens in the air-lift pump. Each bubble of air that is introduced into the tube at the lower end acts as a slug of compressed air, and the water above it acts as a piston that is raised by the tendency of the air to expand or by its actual expansion.

While the action of the pump can be thus described in theory, it has been found in actual practice that it is not feasible to introduce slugs of air in the way shown in the diagrams. If the air were introduced into

the eduction pipe in large bubbles, there would be so much slip that the pumping action would be very inefficient. Therefore, the compressed air is broken up into many very small bubbles which will, with the water, fill the entire pipe.

In Fig. 3 a diagrammatic view of the air-lift pump is shown. Assuming that the tube in Fig. 2 is replaced

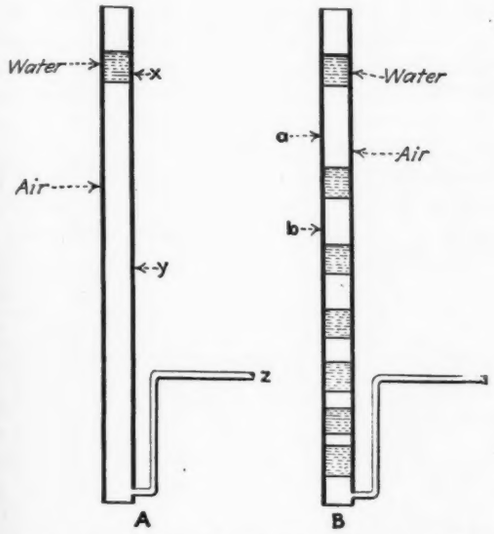


Fig. 2—Action of air on pistons in pipe with closed bottom

in Fig. 3 by the pipe, there is a new problem to be considered: *the bottom of the pipe is open.*

It is obvious that when the sealed lower end of the tube, or pipe, is removed, something must be substituted for it if the sequence of events just described is to occur. In order to seal the lower end of the tube and at the same time permit the entrance of water, the tube or pipe is extended into the water to be pumped to a depth required for the height to which the water is to be raised.

Water Acts Like Solid End of Pipe

Now, this has a bearing on the theory of the air-lift pump. If the theory of the difference in specific gravity is accepted, it is necessary to regard the water outside the pump as the actuating force in performing the work of pumping. On the contrary, the water outside of the discharge pipe merely acts in the capacity of a solid end of the pipe, as indicated in Fig. 2. It has nothing more to do with the pumping action than if a metal cap were placed on the end of the pipe, except that it must have sufficient resistance to prevent the air rushing out, just as a metal cap would have to have a certain strength to resist fracture due to the pressure upon it.

Therefore, the pumping action is the result of the displacement of the water by the air and of the energy in the air by reason of its compressed condition.

The operation of the air-lift pump may be seen from Fig. 3. The discharge, or eduction, pipe is placed in the water to a depth proportionate to its height above the pumping level. There are two levels of the water to be considered—the *standing* level of the water and the *pumping* or working level, the latter being the level when the pump is in operation. The *lift* is the height above the working level to which the water must be raised. The *submergence* is the distance between the working level and the point of introduction of air to the eduction pipe.

The proportion between the lift and submergence in any given pump is determined on the basis of the lift. For ordinary practice it has been found satisfactory to have the submergence about 60 to 65 per cent of the total length of the pipe. If the well or source of water being pumped is deep enough, it is possible to pump water to great heights. Of course, the deeper the submergence the greater is the air pressure required to produce the action.

At no time can the weight of water and air in the pipe above the level of the introduction of air to the pipe, exceed the weight of a like column of water outside the pipe between the surface of the water being pumped and the point at which the air is introduced into the pipe. If this condition were encountered, the pump would fail just as would a pump of the reciprocating type whose cylinder head had fractured.

Introducing air to the discharge pipe through the air line at the point *d* means that the air seeks the easiest way out and therefore bubbles up through the water in the pipe. In this bubbling process the air, rushing upward, entrains the water with it. A sufficient quantity of air is therefore required to keep the water flowing upward.

Some Losses Occur

Several losses occur in pumps of this type. There is, first, the friction loss due to the water moving through the pipe. Second, there is the loss due to slip,

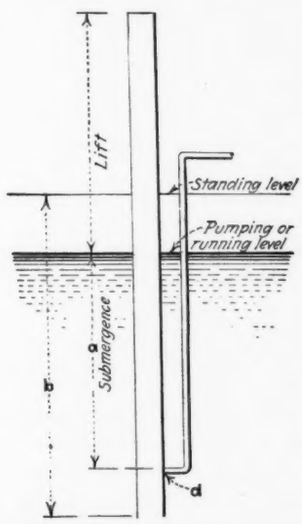


Fig. 3—Diagram illustrating terms commonly used in connection with air-lift pumps

which means that a quantity of air passes through the pipe, permitting water to drop back. The air thus passes through the pipe without performing any useful work.

The third loss is in the velocity with which the water and air emerge from the discharge pipe. The ideal condition would be to have the air discharge into the atmosphere at a pressure slightly above atmospheric. The water would discharge with practically no velocity. It is obviously impossible to pump water by the air-lift method under such ideal conditions and therefore the energy expended in discharge velocity is a loss.

In making calculation for the actual working of these

pumps, these three losses are added to the actual lift of the pump.

The size of the bubble of air used has been found to have a great influence upon the efficiency of the pump. It has been found that the slip of the pump is greater with large bubbles than with smaller ones. This fact has led to the design of various methods of introducing the air at the bottom of the pipe.

Various kinds of "foot-pieces" have been devised, all having as the objective the introduction of the air in the most efficient manner. These foot-pieces are castings or tubes having perforations of different types which break up the compressed air into numerous small bubbles.

There are three methods of introducing the air to the discharge or eduction pipe. In one of these the air line is outside the eduction pipe and is tapped into it at its lower end. Another method is to have the air line form a center pipe in the eduction pipe. The third method is to introduce the air through an external concentric pipe, the internal pipe forming the discharge or eduction pipe.

The Air Lift Pump Has Many Good Points

There are many advantages derived from the use of an air-lift pump. For one thing, the efficiency is maintained at its original percentage without cost or attention. There is no wear of parts to affect it in any way. Impurities in the water, or grit or sand, do not destroy any part of the pumping equipment.

All mechanical equipment is above ground where the parts can be inspected and taken care of in the best manner. This equipment comprises nothing more than the usual air compressor with its drive, intercoolers and receiver, etc.

It is also claimed that more water can be obtained from the same wells using the air-lift pump than by any other method of pumping. This is a factor of considerable importance in some parts of the country where water is difficult to obtain during certain seasons of the year.

It has been said also that the aëration of the water that results from using this method is beneficial to the condition of the water. This, however, is quite doubtful and is wholly dependent upon the purity of the compressed air in use. Properly designed and operated compressors will produce compressed air in such a condition that it will actually purify the water. Impure unfiltered intake air, over-lubrication of the compressor, maintenance of a dirty compressor system or inadequate oil and moisture separators will tend to produce air detrimental to the water pumped. These considerations are of importance where the water is to be used for manufacturing ice, for chemical or other processes requiring pure water.

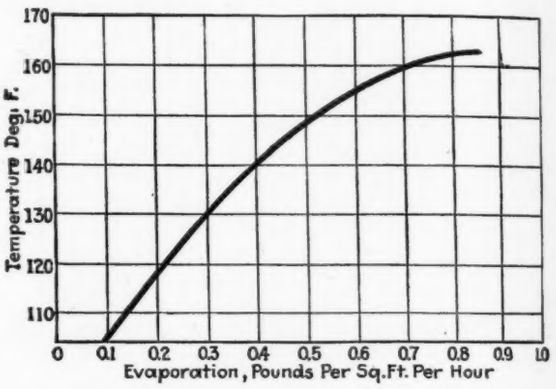
There are several obvious disadvantages, among which may be mentioned the limitation of the height to which water may be pumped. The height is limited by the depth of the water and the submergence.

In general, the air-lift pump serves many useful purposes and if designed and installed to meet the conditions of each installation in the most efficient manner, it provides an efficient, continuous, non-pulsating flow of water. It may also serve in other capacities such as pumping acids, and other chemicals, where ordinary types of reciprocating or centrifugal pumps could not be used.

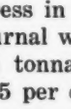
Loss by Evaporation When Weighing Hot Water

When making turbine tests, the accepted procedure is to weigh the cold condensate in weigh tanks. It sometimes happens, however, that the plant layout makes it necessary to weigh hot water instead of cold. Such a procedure, if the water is over 120 to 130 deg. F., is recognized as giving inaccurate results because a portion of the turbine condensate is lost by evaporation. For the purpose of finding the magnitude of the error, the Electric Illuminating Company of Boston has made tests to determine the weight of water lost by evaporation at various temperatures.

The outlet valve of a weigh tank 8 ft. by 7 ft. 4 in. by 11 ft. deep was sealed tight. The tank was then filled with water at 118 deg. F., and temperature and weight readings were taken every 15 minutes for a period of two hours. The test was repeated with water at temperatures of 158 and 167 deg. F. From these data the curve in the illustration was plotted. The weight of water lost is plotted in pounds per hour per square foot of water surface. It is felt that under different circumstances the results obtained will vary from those shown in the curve, and it is hoped that more data of similar nature will be obtained.



Evaporation from tank containing water at various temperatures



In Its April Issue, *The Motor Ship*, London, gave a summary of the progress in motorship building since the first issue of the journal was published seven years ago. At that date the tonnage of motorships under construction was about 5 per cent of that of steamers. At the present time it is approximately 90 per cent. In 1920 motorships represented but 2 per cent of the steamer tonnage completed throughout the world. The corresponding figure for the last year is 85 per cent. Seven years ago oil-engined ships of under 750,000 tons gross were in service; now they total over 4,500,000 tons gross. In 1920 the first motor passenger liner had yet to be completed. Contracts are now in hand for 24 large oil-engined liners of a total tonnage of over 350,000 tons gross. It is a significant fact, as showing the widespread popularity of the motorship at the present time, that the cargo and passenger vessels of this type now on order will be owned by 130 different companies.

Cost of Oil-Engine Maintenance

An Impartial Discussion of What Repair Costs Should Be—Outline of Proper Way To Figure Maintenance—Why Some Plants Have Heavy Repairs

By EDGAR J. KATES*

THE unanimity of opinion concerning the fuel economy and the reliability of Diesel engines does not exist in the case of maintenance costs. On the contrary, there is probably no subject connected with Diesel engines on which there has been more diversity of opinion and greater variations in the supporting data.

No one doubts today that a Diesel engine will do more net work for a given heat input than any other common prime mover. Thermal efficiencies of 34 to 36 per cent based on brake horsepower output are the usual figures and are attained by small engines as well as large. In a steam plant the fuel consumption per unit of output will sometimes increase considerably though the load is being carried satisfactorily and there are no striking symptoms of derangement. A leaky boiler setting or a careless fireman will completely undo every effort toward high efficiency incorporated in the plant design.

That is not so with the Diesel engine. If it is fit to run at all, it will always consume practically the same amount of fuel per horsepower-hour. The combustion of the fuel and the conversion of heat energy into mechanical work take place under controlled conditions that always produce the same results. Only if the engine be in bad physical shape or if it be heavily overloaded, does the fuel efficiency decline, and such a condition is always evidenced by symptoms that are strikingly clear, even to the inexpert.

The reliability of Diesel engines is today hardly questioned. Records of numerous plants running under various conditions have uniformly testified to a remarkably low percentage of time out for repairs. One of the large oil-pipe lines has been running 42 engines on continuous heavy load, 24 hours a day, 365 days a year for over 15 years, without any spare units. This company reports that the engines have been on duty over 98 per cent of the time, and at present it has 150 units of over 20,000 hp. total capacity. In many plants the load is not continuous and the engines are accordingly shut down each day or each week. In such cases adjustment of bearings, cleaning of spray nozzles, etc., are done when the engines are not needed in service, and many such plants have shown a 100 per cent performance record.

The cost of maintenance depends largely upon the operating conditions, such as load factor, hours of service and skill of the attendants. From records that have been made public, one can find plants in which the cost of upkeep per horsepower is ten times that of other plants. At first thought one might attribute this variation to some uncertainty of performance inherent in Diesel engines, but closer study will show that this is not the case. The circumstances of operation fix the maintenance costs. This has been definitely proved in plants where a number of similar engines have been run under similar conditions of loading and attendance. In several such plants the records covering a number of years show practically identical costs of maintenance for each engine. This is to be expected, because the established manufacturers of Diesel engines rigidly control the materials and workmanship entering into their product, with the result that the engines turned out are quite uniform in quality. Variations in performance of engines of one make are seldom the result of differences built into them in the factory, but are almost always the effect of the circumstances under which the engines work. Of course there are exceptions which simply go to prove the rule. It is possible for a hidden flow to cause a crankshaft breakage, but such cases are now rare since the blemished forgings of war-times have disappeared.

How to Reduce Maintenance

If low repair costs are desired, a Diesel engine should never be overloaded. Sometimes such overloading is beyond the control of the operating force, as in the case where an engine is direct-connected to a reciprocating pump that must deliver against a fixed discharge pressure. In this instance the torque is fixed by the pump dimensions and the gear ratio, and if this torque exceeds the engine rating, the engine is bound to be overloaded every time it runs. In many other cases, such as where there are several generating units operating in parallel, the load conditions are under the control of the engineer, and overloading is avoidable. But whether overloading results from plant design or from operation, it must be avoided in order to assure a low cost of maintenance.

Engineers familiar with steam engines and turbines, and their ability to carry large overloads satisfactorily except for a reduction in thermal efficiency, sometimes wonder why the Diesel engine, if conservatively rated,

*Consulting engineer, New York City.

cannot do likewise. Overloading steam equipment increases simply the mechanical stresses and affects but little the comparatively small heat strains. In a Diesel engine, however, the normal rating is determined not so much by the factor of safety on the mechanical stresses, but rather by the ability of the materials to withstand the strains resulting from the high temperatures. When a Diesel engine is overloaded, more fuel is burned within the same space and the temperatures are increased, thus putting greater heat strains on pistons, cylinders, cylinder-heads and valves. Furthermore, the combustion, when an excessive amount of fuel is being consumed, is not completed as early in the stroke, and the engine parts are therefore subjected to the abnormal temperatures for longer sustained periods. The upkeep of these parts will of course considerably increase the maintenance costs.

Effects of Overloading

In the early days of the oil engine, the manufacturers did not lay sufficient emphasis on the harmful effects of overloading. One of the first oil pipe lines to use oil-engine drive in its pumping stations put in a number of engines the rating of which was practically equal to the normal load. Occasionally, overloads would occur due to the pipe-line pressure rising above normal. The load, as on any pipe line, was a continuous one. The repair expense on these engines was high, approximating ten dollars per year per rated horsepower. On modern pipe lines it is general practice to select the engine size large enough so that the normal load will be 85 to 90 per cent of the engine rating. Though this means a somewhat larger initial investment, it is more than repaid by the low maintenance costs that are thereby obtained, a well-run pipe-line system showing a repair expense of about two dollars per year per rated horsepower. Some of this improvement is, of course, due to the superior design and construction of modern engines and to greater understanding on the part of the engineers. Nevertheless, a great deal of the excessive repair costs of the early days was undoubtedly the direct result of overloading.

Three methods of presenting maintenance costs on a unit basis are commonly used—cost per horsepower-hour, annual percentage of initial cost, and annual cost per rated horsepower.

How to Calculate Maintenance

Cost per horsepower-hour is a basis that is imperfect in several respects. An engine that is started and stopped frequently will cost more for maintenance than the same engine delivering the same number of horsepower-hours, but with fewer starts and stops. This is because during the starting period, lubrication is imperfect, and the pressure and temperature conditions are not as stable as when the engine is running steadily.

For similar reasons, maintenance expense is related to the steadiness of the load, a uniform load being more conducive to low costs than one that varies between wide limits. Take, for example, an irrigation-pump installation and a factory power plant. The irrigation service requires 24-hour-a-day operation for 3 months a year at a steady load of 90 per cent. The factory drive requires 8-hour-a-day operation for 300 days a year at a load varying between 50 and 110 per cent of rating and averaging 80 per cent. In this case the output of the two plants, in horsepower-hours, is practically the same, but the factory plant is bound to have a higher cost of maintenance and would therefore make an unfavorable showing on this unit basis.

There is another objection to the cost per horsepower-hour basis. In ice plants the overhaul work must be done each winter and the cost of doing it varies but little with the amount of work the engines did during the previous summer season. Consequently, if the ice business was bad and the engines were not used as much as usual, the maintenance cost per horsepower-hour will appear to be excessive through no fault of the engines or engineers.

Expressing the annual cost of maintenance as a percentage of the initial cost of the engines is a method frequently used. It avoids some of the faults of the horsepower-hour basis, but introduces others. Two engines of the same power but of different types may differ 50 per cent in initial cost. If each has the same annual repair costs when operating under the same conditions, the percentage of initial cost will be greater for the cheaper engine; in other words, it will be penalized for its lower initial cost.

Percentage Varies with Engine Cost

The same objection occurs when comparing the records of engines built during the War period with those built before or after that time. War-time engines cost twice as much as the others, but surely that is no reason why their present-day repair cost should be permitted to be double that of better engines built before or after the War. Yet that is the very inconsistency introduced by comparing maintenance costs on a basis of percentage of engine price.

The annual cost of maintenance per rated engine horsepower, while not by any means perfect, is probably the best basis for general use. It varies, of course, with the amount of use made of the engine, and therefore this should be stated or the class of service indicated, so that one may draw one's own conclusions.

TABLE I—COMPARISON OF VARIOUS METHODS FOR EXPRESSING MAINTENANCE COST ON UNIT BASIS

200-hp. engine with an annual maintenance cost of $250

Class of Service	Maintenance Cost on Unit Basis			
	Cents per Horse-Power-Hour	Annual Per Cent of Initial Cost		Dollars per Year per Rated Horse-Power
		Engine Cost $55 per Hp.	Engine Cost $110 per Hp.	
Light duty, 130,000 hp.-hr. per year, such as standby service, 90 per cent load, 24 hours per day, 30 days per year	0.193	2.27	1.14	$1.25
Medium duty, 385,000 hp.-hr. per year, such as factory power, 80 per cent average load, 8 hours per day, 300 days per year.; central station, 22 per cent average load, 24 hours per day, 365 days per year; irrigation, 90 per cent average load, 24 hours per day, 90 days per year	0.065	2.27	1.14	1.25
Heavy duty, 1,300,000 hp.-hr. per year, such as on oil pipe lines, 90 per cent load, 24 hours per day, 300 days per year	0.019	2.27	1.14	1.25

Table I shows the various ways in which the same annual maintenance cost may be expressed.

Maintenance records, to be of the greatest value, should cover a span of years long enough to encompass the life of the main wearing parts such as pistons, cylinders and crankshaft bearings. Obviously, during the first few years of an engine's life no replacements of these large parts are required, and the records will accordingly show a low cost of repairs. In some subsequent year, however, the pistons, cylinders and bearings will have worn out and will have to be replaced. The cost of doing this, if charged against the operations of that one year, will appear quite out of line with the fig-

ures for preceding years. Inasmuch as these parts have been wearing from the time they were new, the cost of replacing them should be distributed over the entire period of their life. Such a distribution is obtained by averaging the maintenance cost records over a sufficiently long period of years.

Failure to average maintenance costs over several years is one of the reasons for the divergent figures so often quoted. A complete overhaul of a 200-hp. engine may cost $900. If this be charged off in one year, it will appear on the records as a cost of $4.50 per year per horsepower. However, if such overhauls are made at intervals of six years, their real cost is only $0.75 per year per horsepower.

TABLE II—REPAIR COSTS OF OIL ENGINES IN ICE PLANT SERVICE

Equipment—One 140-hp. engine put in service April, 1916; one 40-hp.engine put in service April, 1916; one 140-hp. engine put in service Dec., 1919

Year	Horsepower Installed	Cost of Repairs	Repair Cost Dollars per Year per Horsepower*
1916	180	$104.75 (8 mos.)	$0.88
1917	180	1,057.22	5.87
1918	180	133.61	.74
1919	180	358.61	1.99
Average, 1916 to 1919			2.37
1920	320	893.21	2.79
1921	320	643.03	2.01
1922	320	626.02	1.96
1923	320	634.45 (10 mos.)	2.38
Average, 1920 to 1923			2.29
Average, 1916 to 1923			2.33

*12 months' basis.

Table II shows the repair costs of surface-ignition oil engines in an ice plant in the neighborhood of New York City. None of the engines was new when installed; all of them had been in regular service elsewhere for several years. This accounts for the high repair cost in 1917, a number of major replacements having become necessary at that time. During the first four-year period the installed horsepower was 180 and the average annual repair cost was $2.37 per horsepower. Throughout the second four-year period the engine ratings totaled 320 hp. and the average annual repair cost was $2.29. The consistency is striking. Figuring the maintenance cost each year as a percentage of the replacement value of the engines in that year, the average annual maintenance works out to 1.89 per cent of the replacement value.

TABLE III—REPAIR COSTS OF OIL ENGINES IN PIPE LINE SERVICE

Station A—Seven 100-hp. engines installed in 1914; Six engines in continuous operation 24 hours per day.
Station B—Seven 100-hp. engines installed in 1914; Six engines in continuous operation 24 hours per day.

Station and Year	Cost of Repairs	Repair Cost Dollars per Year per Horsepower
Station A 1917	$1,090	$1.56
1918	1,690*	2.42
1919	1,084	1.55
Yearly average	$1,288	$1.84
Station B 1917	974	1.39
1918	770	1.10
1919	2,440*	3.48
Yearly average	$1,395	$1.99

*The higher cost is due to general overhauling during this year.

Table III gives the repair costs of fourteen 100-hp. oil engines in oil pipe-line service. There were seven engines in each of two pumping stations. In each station six engines were in operation at all times; in other words, the running factor was about 85 per cent of the total hours of the year. During the period recorded, general overhauling was done in each station. The average annual repair cost per horsepower in one station was $1.84, and in the other station $1.99.

TABLE IV—REPAIR COSTS OF DIESEL ENGINES IN MUNICIPAL WATER-PUMPING SERVICE

Equipment—Two 225-hp. engines installed in 1914. Both engines running about 5,700 hours per year.

Year	Cost of Repairs	Repair Cost Dollars per Year per Horsepower
1915	991.38	$2.20
1916	571.78	1.27
1917	364.74	.81
1918	553.01	1.23
1919	571.25	1.27
1920	608.49	1.35
Annual average		$1.36

Table IV shows the maintenance expense in a municipal water-pumping plant containing two 225-hp. Diesel engines running about 65 per cent of the total hours of the year. The record covers a period of six years, during which the average annual repair cost per horsepower was $1.36.

Answers to What Do You Know

Ans. 1—At the M. K. T. Ry. shops at Parsons, Kans.

Ans. 2—If a sheet is laminated or is unduly thick, or if there is scale on the water side, it is possible for the other surface to become overheated due to the temperature gradient through the sheet.

Ans. 3—The frost is due to the expansion of the air lowering the air temperature below 32 deg. F. and causing the entrained water vapor to settle as frost. Heating the air before it reaches the engine will cause the exhaust temperature to be above the frosting point.

Ans. 4—Herbert Ackroyd Stuart was the inventor of the oil engine in which combustion is effected either by a hot surface or by the heat of compression.

Ans. 5—As the air is mixed with ammonia vapor, some of the latter will escape with the purged air. The lower the temperature the smaller the percentage of ammonia lost.

Ans. 6—As a centrifugal pump cannot evacuate its casing and suction line of air, it is necessary to have a foot valve which, when the pump is stopped, will retain the water in the pipe and casing or, if the water is lost, will be tight enough to permit the line to be filled before starting.

Ans. 7—The line should slope away from the boiler to prevent accumulation of condensation at the boiler stop valve when it is closed.

Ans. 8—Marine engines using saturated or wet steam are operated without cylinder lubrication in many instances.

Ans. 9—Carbon rings, labyrinths, water seal.

Ans. 10—It is best to let the water level drop to the second gage before blowing down in order that the concentration per unit volume of water to be blown down be as high as possible. In this way a greater percentage of the foreign matter is blown out.

EVEN WHERE EVAPORATORS ARE USED with surface condensers, it is not possible to prevent entirely the entrance of scale-forming salts into the feed-water system, because the condenser leakage cannot be reduced to zero. Condenser leakage, in large power plants, is frequently one per cent of the feed water. This is sufficient, if not properly treated, to occasion considerable expense, either in the frequent turbining of the boiler tubes or in the losses resulting from tube failures.

*The questions will be found on page 772.

Application of Direct-Connected Synchronous Motors to Carbon Dioxide Compressors*

By D. W. McLENEGAN
General Electric Company, Schenectady, N. Y.

THE use of direct-connected synchronous motors with CO_2 compressors brings up problems both in torque requirements and flywheel requirements which are different from the requirements of corresponding ammonia compressors, and this problem is more misleading at first thought, because the recommendations for some types of CO_2 compressors are practically identical with the recommendations for the corresponding types of ammonia compressors, whereas for other types they are widely different. The single-acting vertical types are, from the motor viewpoint, very similar to ammonia compressors. The other two types, however, have somewhat different requirements. The cause of the unbalance which requires a greater starting torque and a greater flywheel effect for the CO_2 compressors can best be illustrated by comparing a single-cylinder, double-acting CO_2 compressor to a single-cylinder, double-acting, ammonia compressor. As nearly as the writer can determine from the standard practice of various compressor builders, the CO_2 machine would have a piston rod of a diameter that would make the crank-end piston area 25 per cent less than that of the head end. In the ammonia compressor the crank-end area is decreased only 4 per cent in comparison to the head-end area by reason of the larger cylinder. In comparison to the unbalance which occurs in the CO_2 compressor, this is practically negligible.

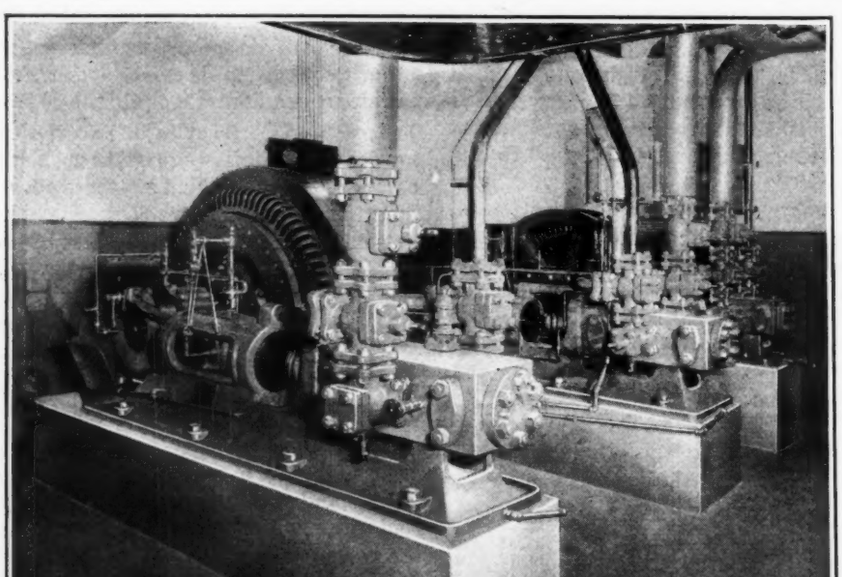


Fig. 1—Twin double-acting CO_2 compressor with flywheel effect in the synchronous motor rotor

However, the difference in area between the two ends of the CO_2 compressor cylinder would not account for any great increase in starting torque, except for the high suction pressure. With a suction pressure of 400 lb. on both sides of the piston of the CO_2 compressor, the motor must develop torque enough to push the piston on the first stroke from the crank end to the head end against a force of 400 lb. times the area of the piston rod, since there is nothing but atmospheric pressure behind the end of the piston rod which projects cut through the crank end of the cylinder. Also, owing to this unbalance the compressor will always come to rest with the piston near the crank end of the stroke, which means that the piston will always be in the most unfavorable position for overcoming the unbalance when starting up again, and will have no opportunity to gain any speed before encountering this unbalance. If the compressor has been shut down for some time and the pressures in the system have equalized, the motor may have to start the compressor with a pressure of 50 or 55 atmospheres in the cylinder.

There are two possible methods of overcoming the necessity for high starting torque on the single cylinder, double-acting CO_2 compressor. It is possible to pump out the cylinders and thereby reduce the unbalance to a point where a motor of normal design can turn the compressor over against whatever unbalance remains. The other possibility would be to extend the piston rod out through the head end of the cylinder and in this way make both ends of the cylinder alike. However, this expedient is open to the objection that it requires packing the head end as well as the crank end and, to the writer's knowledge, has not been used.

The abnormal torque required at starting does not continue as the motor comes up to speed. The extra work that is done in pushing the piston from the crank end to the head end against the unbalance, is recovered on the return stroke, where the unbalance aids the motor. As soon as the motor reaches a speed at which

*Abstract of paper read before the seventeenth annual convention, National Association of Practical Refrigerating Engineers.

the flywheel can partly smooth out the unbalance, the torque requirement is reduced, since the net work required by the unbalance throughout one revolution is zero. At pull-in the CO_2 compressor does not require any greater torque than the corresponding ammonia compressor, except for the fact that it will have a relatively larger flywheel and provision must be made for accelerating the motor and the larger flywheel to synchronous speed when the excitation is applied.

In the case of the two-cylinder double-acting machine with cranks at 90 deg., the motor still has an unbalance to overcome at starting, although this unbalance is not as great a percentage of the full load torque as it is in the case of the single-cylinder machine.

Neglecting the effect of friction, the machine would come to rest with both cranks 45 deg. away from the crank end, dead-center position. The maximum unbalanced torque would occur 90 deg. later; that is, with one crank 45 deg. ahead and the other 45 deg. behind the mid-stroke position. As in the case of the single-cylinder machine, there is only one-quarter turn before the point of maximum resistance is reached, and therefore the motor can gain no appreciable momentum to help it in overcoming the unbalance.

Although no easy means has yet been found for reducing the requirements of the single-cylinder CO_2 compressor, the situation with regard to duplex double-acting compressors, Fig. 1, has been simplified by changing the angle between cranks from 90 deg. to 180 deg. The power requirement of the crank end stroke of one cylinder is then added directly to that of the head end stroke of the other cylinder. The unbalance at starting is eliminated, because the equal forces on the pistons, being directed toward the crank end, produce two equal and opposing torques at the motor shaft. The change to 180-deg. crank spacing necessitates some changes in the compressor piping, since the gas is discharged in two impulses per revolution instead of four, but the difficulties arising from this fact have been overcome, and the 180-deg. setting for these machines has been standardized by several of the manufacturers.

The advantage of being able to reduce the required starting torque to a normal figure does not lie entirely in the lower cost of the driving motor. Other conditions remaining equal, high starting torque involves high starting current. This is especially undesirable in the installations where motor-driven compressors have found their greatest application, namely, motion picture theaters, dance halls and other buildings which accommodate large crowds of people. The electrical supply for such buildings is frequently a regulated circuit, sometimes carrying a lighting load. The effects of a heavy current inrush may be evidenced by a flicker of all the lights on the circuit. Furthermore, the 180-deg. crank setting makes it possible in most cases to include the necessary flywheel effect in the motor rotor, while the 90-deg. crank setting requires a large additional flywheel, or an oversize motor designed especially for flywheel effect. Since the headroom and the floor space are usually limited, and the installation or removal of the equipment is generally difficult, the elimination of the flywheel is an advantage far beyond the saving represented by the cost of the wheel itself.

The vertical double-acting machines with two or three cylinders, have simpler torque requirements than the horizontal machines. Such compressors, Fig. 2, are short-stroke, high-speed units. Probably because of the shorter stroke, which means a shorter piston rod, the rod can be made smaller in proportion to the piston area than it would be on a long-stroke, horizontal compressor.

In the designs now in use the piston rod reduces the crank-end area by 12 to 15 per cent, and therefore the unbalance is not as bad as encountered in the horizontal machines. From the view of starting torque it has been found feasible to retain the 90-deg. crank setting for these compressors. Since synchronous motors can sometimes be applied to these compressors without requiring any addition to the flywheel effect of the rotor, the torque necessary to overcome static friction is very small, and it has been found that motors of normal design and average torque can take care of both the friction load and the unbalance at starting.

The three-cylinder vertical double-acting compressor is balanced, due to the 120-deg. spacing of the cranks, and is, therefore, easily motorized both as to torque and

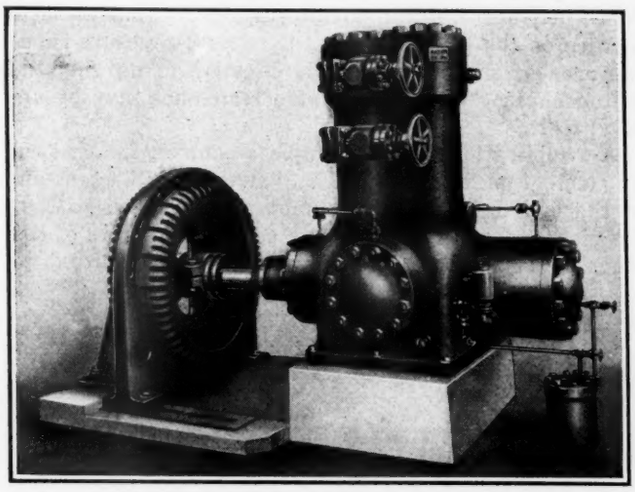


Fig. 2—A typical two-cylinder single-acting CO_2 machine without flywheel

flywheel effect. The starting torque required is only sufficient to overcome the mechanical friction and the friction of the gas in the bypass.

In passing, it is well to mention the effect which the use of clearance pockets would have on the flywheel requirements. Calculations have been made with 90-deg. crank setting to find whether additional clearance could be used to balance the head end against the crank end, and so avoid the necessity of the 180-deg. crank setting. Various amounts of clearance were tried, but no satisfactory balance was found. If a clearance pocket is used on the head end, a large percentage of the normal work is done on the compression stroke, but some of it is returned on the expansion and suction strokes. However, the returned energy does not come at the right part of the stroke to offset the effect of the reduced crank-end piston area. Another point is that a clearance pocket, designed for a certain reduction of capacity with given pressures, will have a different effect if the compression ratio is changed, and the results will vary with the operating conditions of the plant. Experience indicates that some compromise may be necessary in choosing the flywheel effect for a compressor with clearance pockets, unless it is possible to bring the natural frequency below the revolutions.

Why Is a Double Eccentric Used?

THE principal limitation of the simple D-slide valve is eliminated by the double eccentric gear, and an efficient means of governing is provided. A throttle governor deliberately reduces the available energy in all the steam supplied to the engine, while a cutoff governor utilizes all the energy available in a smaller quantity of steam.

THE elementary reciprocating steam engine consists of a cylinder fitted with a piston in front of which steam is admitted through an automatically controlled valve. The steam in the cylinder exerts a force on the piston equal to the steam pressure times the area of the piston, and is effective in pushing the piston against whatever outside resistance may be applied to it.

An application of this simple steam engine is seen in small duplex pumps. The valves admitting steam to the cylinders of these pumps are arranged so that the piston of one cylinder operates the slide valve of the other in such a way that live steam is admitted to

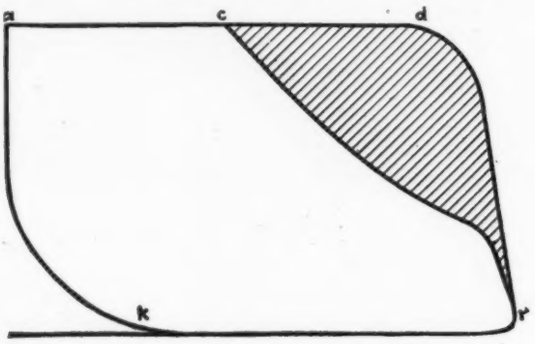


Fig. 1—Cutoff improves economy

the cylinder throughout the entire stroke. This steam, when exhausted from the cylinder, is at nearly full steam pressure and is therefore as useful as when first admitted to the cylinder. To throw away live steam in this way is certainly a wasteful procedure, and in a large engine a lot of money may be lost in the course of a year.

Some of this waste can be prevented by cutting off the steam supply to the cylinder before the piston reaches the end of its stroke. The steam trapped in the cylinder when cutoff occurs will expand as the piston continues to move to the end of its stroke. The expanding steam, although its pressure continually decreases during expansion, nevertheless exerts a force against the piston and does useful work. The exhaust steam in this case is at a pressure less than main steam pressure and consequently has less useful energy stored in it.

The indicator card of an engine taking steam during the entire stroke is shown by *acdrk*, Fig. 1, and superimposed on it is the card of an engine operating with cutoff occurring at *c*. The volume of steam between *c* and *d* is the decrease in steam supplied during each stroke, and the cross-hatched area represents the accompanying decrease in available work due to the reduction in mean effective pressure acting on the piston. By making use of the expansion of the steam as shown in Fig. 1, 53 per cent of the original steam consumption produced 72 per cent of the original work developed and a 36 per cent improvement in economy. This saving

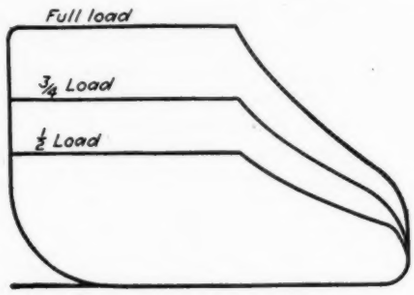


Fig. 2—Throttle governing

will increase, and less useful energy will be thrown away in the exhaust as the steam supply to the cylinder is cut off earlier in the piston stroke, best economy being obtained when it occurs at about one-quarter stroke.

When cutoff is fixed and cannot be adjusted, the engine load can be controlled only by regulating the steam pressure entering the cylinder. This method of governing, shown by the indicator card Fig. 2, deliberately reduces the energy available per pound by throttling the steam.

The point of cutoff terminates the period during which full steam pressure is exerted against the piston.

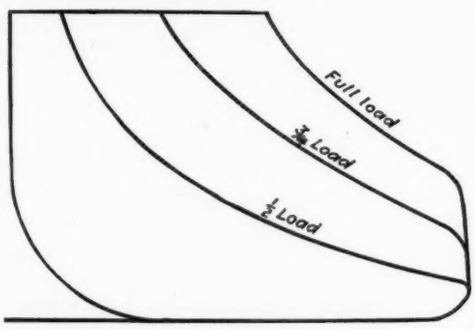


Fig. 3—Cutoff governing

With late cutoff full steam pressure is effective for a large part of the stroke and the mean effective pressure will be high, while when it occurs early full steam pressure acts against the piston for only a small part of the stroke and the mean effective pressure will be low. Thus the power delivered by the engine will be large or small depending upon the point of cutoff. Fig. 3 shows the indicator card of an engine governed by controlling the point of cutoff. In this case a larger part of the available energy in a smaller quantity of steam is utilized.

The point of cutoff of an engine provided with a D-type slide valve operated by a single eccentric, is determined by the valve steam-lap, Fig. 4, and by the position of the eccentric with respect to the crank. A small steam lap gives late cutoff, while increasing the lap causes it to occur earlier. A change in the length of the steam lap also changes the point in the stroke at which steam is admitted to the cylinder, while a change in the position of the eccentric affects all valve

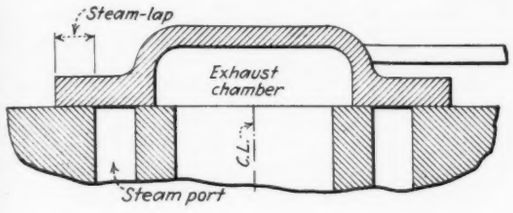


Fig. 4—The D slide valve

events. If an attempt is made to obtain cutoff at, say, one-quarter stroke by increasing the steam lap, it is found admission occurs too late and the engine will operate poorly and with low efficiency. This difficulty can be remedied by increasing the advance of the eccentric ahead of the crank, but in doing so exhaust and compression are made to occur too early. Fig. 5 shows the type of indicator card resulting from an attempt to secure too early cutoff.

There is, then, in the ordinary slide-valve engine a practical limit beyond which this principle of early cutoff cannot be carried. The simple slide valve is ordinarily not used to give cutoff earlier than five-eighths to three-quarters of the stroke, and therefore the best economy cannot be obtained.

These difficulties encountered in the D slide valve may be eliminated, and early cutoff secured by the addition of an auxiliary valve, as shown in Fig. 6, operated by a separate eccentric. The main valve is provided with a dummy end which forms a separate port which the auxiliary valve opens and closes. In this double-

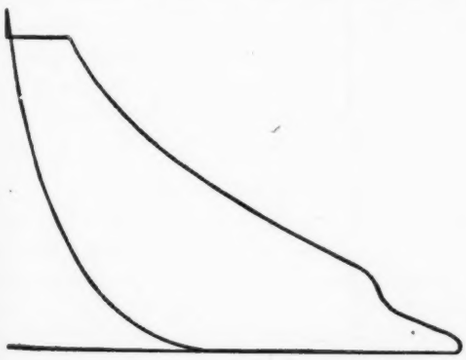


Fig. 5—Effect of too early cutoff with D slide valve

eccentric type valve the main eccentric and valve control admission, exhaust and compression in the same manner as the D slide valve. The duty of the auxiliary valve is to control only the cutoff by closing the port *W* in the main valve. When the main and cutoff eccentrics are set together, the two valves will travel together, the point of cutoff being determined by the design of the main valve, and will occur when the main valve closes the steam port in the cylinder. If the cutoff eccentric is set ahead of the main eccentric, the cutoff valve will reach the end of its stroke and start moving back before the main valve has completed its stroke. As shown in Fig. 7, the auxiliary valve will cover the port *W* in the main valve, before the main valve closes the cylinder steam port, causing cutoff to occur earlier in the stroke. It is evident that the position of the second eccentric with respect to the main eccentric can be adjusted so that the auxiliary or cutoff valve will close the port *W* at any point in the stroke, and thus cutoff may be made to take place early or late, as desired.

Since with constant steam pressure the point of cutoff determines the power the engine will develop, a gov-

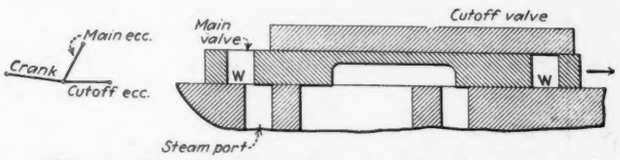


Fig. 6—Double-eccentric operated valve shown admitting steam to cylinder

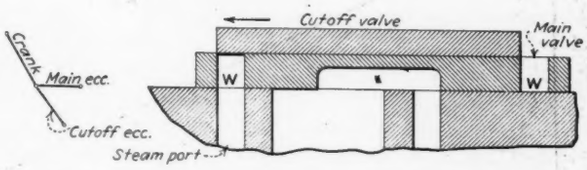


Fig. 7—Double-eccentric operated valve shown at point of cutoff

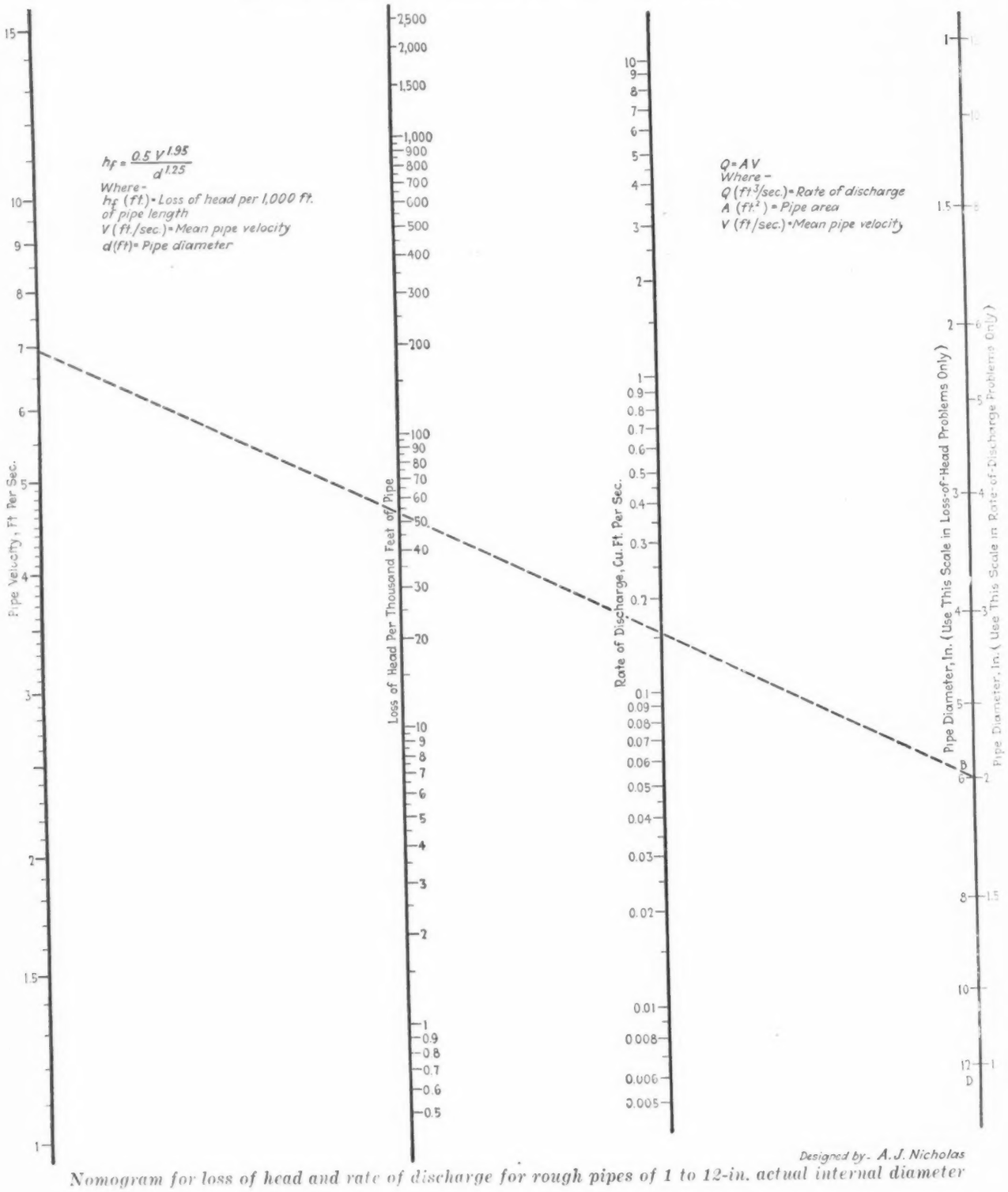
ernor will control the engine if mounted so as to regulate the position of the cutoff eccentric. Thus the double eccentric provides a means of engine governing which makes possible the utilization of full steam pressure at all loads, and an improved engine efficiency.

The Power Prize Contest Is Closed and the Judges Have the Papers

There were 44 papers submitted, and no doubt it will take the judges considerable time to consider these articles carefully before they are in a position to award the prizes. If there is any delay in announcing the winners, the large amount of work entailed in making the awards will account for the cause

Chart Solves Water-Flow Problems

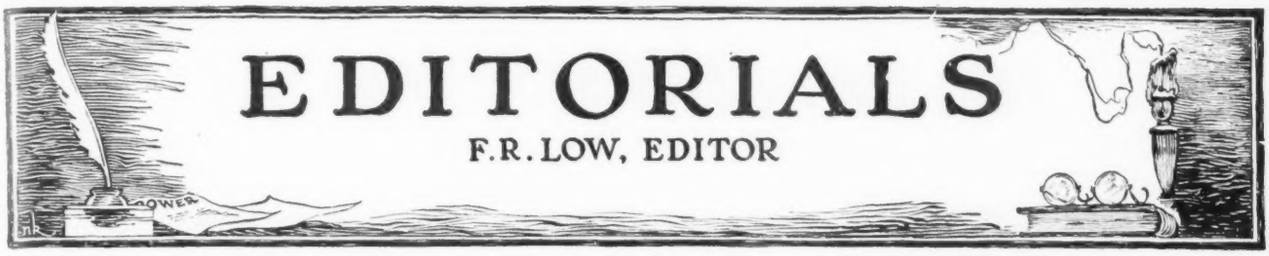
By A. J. Nicholas
Instructor in Mechanical Engineering, the Pennsylvania State College


$h_f = \frac{0.5\,V^{1.95}}{d^{1.25}}$
Where –
h_f (ft.) = Loss of head per 1,000 ft. of pipe length
V (ft./sec.) = Mean pipe velocity
d (ft) = Pipe diameter
Q = AV
Where –
Q (ft³/sec.) = Rate of discharge
A (ft²) = Pipe area
V (ft/sec.) = Mean pipe velocity
Pipe Velocity, Ft. Per Sec.
Loss of Head Per Thousand Feet of Pipe
Rate of Discharge, Cu. Ft. Per Sec.
Pipe Diameter, In. (Use This Scale in Loss-of-Head Problems Only)
Pipe Diameter, In. (Use This Scale in Rate-of-Discharge Problems Only)
Designed by - A. J. Nicholas

Nomogram for loss of head and rate of discharge for rough pipes of 1 to 12-in. actual internal diameter

THE accompanying alignment chart gives an immediate solution of problems involving loss of head and rate of discharge for various water velocities in rough pipes whose actual internal diameter ranges from 1 to 12 in. The formulas are given on the chart. That for loss of head is given by Meier and may be found in Marks' "Mechanical Engineers Handbook."

To find the loss of head from the chart, connect the pipe size with the corresponding velocity in the pipe and read the loss of head at the point of intersection with the loss-of-head line. Thus for a 6-in. pipe and 6.95 ft.-per-sec. velocity the loss of head is 53 ft. per thousand feet of pipe. In the same way a 2-in. pipe at 6.95 ft. velocity gives a discharge of 0.155 cu.ft. per sec.



The Decrease in Students in Mechanical Engineering

MUCH concern has been expressed by many engineers about the decreasing registration of students in the courses of mechanical engineering in the various colleges. It appears that there has been a marked decrease in such registration during the last few years and it is having a noticeable effect on the supply of young graduates. This decreased supply has resulted in calls on the colleges by industries for several times the number of men in the present graduating classes in mechanical engineering. Since many mechanical engineers enter the power field, this matter concerns the power-plant owner as well as the manufacturer.

Let us consider what are the causes of this decrease and what will be its ultimate effect. The recent investigation of engineering education has indicated that almost half the students decide to study engineering before the end of their third year of high school. A private inquiry indicates that they select at the same time the branch of engineering that they wish to follow. This indicates that students select their courses before many of them realize the fields of the various branches of engineering and the probable demand for men in each. They are probably influenced by hearing the radio, by the universal appeal to "do it electrically" and by popular notions that chemistry and electricity will revolutionize our whole industrial life.

Few realize that all these machines must be made and that mechanical engineers are the class who interest themselves with the making of machine parts whether these later become telephones, radio sets, automobiles, steam turbines, machine tools, pipes or steam boilers. The chemist and the electrician come to mechanical engineers to get their machines built. Hence the greater the expansion of chemistry or electricity the greater the need of the mechanical engineer in production work.

Electricity must be generated in power plants which, if of large size, will be in charge of mechanical engineers. Hence an increase in the demand for electricity will automatically increase the demand for the power specialist. It is obvious, therefore, that both power producers and manufacturing industries are interested in this shortage of young engineers.

How can the situation be remedied? If the demand continues, higher wages must be paid to mechanical engineers, and this, in itself, will be an unmixed blessing for, as a whole, engineers are underpaid. This will attract men from other branches of engineering and will again attract students to mechancial courses.

The difficulty is to reach the high school boy who is about to make his decision regarding courses. Probably the most effective influence will be personal contacts with such lads by power engineers who can point out the opportunities and can urge them to follow mechanical engineering.

The situation, while disturbing, is not a serious one. The trend of many college courses is away from specialization so that a man can readily shift from one branch of engineering to another after graduation. This situation may actually prove beneficial in encouraging more fundamental courses in colleges and less specialization.

What About Unaccounted-for Losses?

ENGINEERS are generally supposed to weigh carefully every element of a problem so that there is little chance that the result may be other than predicted, yet occasionally the outcome of a series of developments produces a surprise to those engaged in planning the improvements.

V. E. Alden, in his recent paper on "Present Tendencies in Steam Station Design," calls attention to such a surprising result. He points out that the application of the regenerative cycle for heating feed water together with the use of the motor drive for auxiliaries in modern stations has reduced the unaccounted-for losses from ten to twelve per cent in the older stations with steam-driven auxiliaries to less than five per cent in the new ones using this cycle. This is a remarkable achievement and worth some consideration.

Engineers are now familiar with the elements of the regenerative cycle which contributed to this reduction. Has sufficient consideration been given to these unaccounted-for losses in the older stations? Is there a possibility of making a substantial saving in such plants by reducing these losses? A little consideration will indicate that these questions deserve thoughtful study.

Such losses in the older stations consist largely of steam leakage and condensation from the many small high-pressure steam lines and fittings that are necessary for steam-driven auxiliaries. There are also radiation losses from the large low-pressure lines and the feed-water heaters. It is seldom possible to balance up the demand of exhaust steam to heat feed water with the available supply, and losses of heat through the atmospheric exhaust head are the result.

A study of many stations would indicate that certain wasteful auxiliaries with their steam lines could be economically replaced by modern electrically driven auxiliaries. A careful maintenance system should reduce leakage from valve stems, traps and blowoff valves. A study of boiler-water concentration will indicate whether boilers are blown down too much or too often.

The operator of an old station with steam-driven auxiliaries can devote considerable study to these problems. If he finds that feed-water temperatures are low when motor drives replace steam auxiliaries, he will probably find that certain of his main units can be tapped for bled steam to make up the deficiency, and at the same time he will improve his station performance.

This surprising reduction in losses pointed out by Mr. Alden suggests the need of study of this problem.

Curing Corrosion Is the Engineer's Job

YEARS ago the causes of corrosion were imperfectly understood. That water had something to do with it was generally agreed, but there were questions concerning the influence of air. Moreover, corrosion was not perhaps not as widespread in the power plant as it is today, because the boiler feed water was a natural or treated water, which deposited more or less scale that protected metal against chemical action. Cast-iron economizers were relatively insensitive anyway.

Today the situation is different. Higher pressures have compelled the use of steel economizers, and high steaming capacities have led to the use of distilled water for boiler feed, since the thermal insulating effect of scale would interfere unduly with continuous boiler operation. These changes were made more or less complacently until serious corrosion difficulties were encountered, and then there was a measure of confusion and argument. True, there had been anxiety concerning the corrosion of steel economizers on the gas side, due to sulphurous constituents of the flue gas forming acids when dissolved in water coming from small leaks or from the condensation of water vapor from the flue gas. This difficulty did not materialize, perhaps because a steel economizer does not leak, and because the gas is not cooled to its dew point, but internal corrosion did appear in a vigorous form and, to say the least, was disconcerting.

Here the chemist stepped in to apply his knowledge to determining the causes at work. There was, and there still is, some argument as to the precise nature of the actions occurring, but the basic cause seems now to be definitely identified. Water carrying oxygen in solution is the guilty party. If the oxygen content of the water is reduced to one-tenth of a cubic centimeter per liter of water—one part per ten thousand by volume, or about 1.4 parts per million by weight—corrosion does not occur unless other corrosive agents are present.

This demonstrated, the engineer must resume his active control of the situation. Just as he had to learn enough chemistry to study the composition of his flue gas, so now he must learn enough more to study the oxygen content of his feed water. It is not difficult. Any engineer can learn to make accurate determinations, even though he may not be master of all the intricate things that take place when he mixes various reagents in a flask. The article by Mr. Joos in this issue illustrates the value of doing this. Corrosion indicates the probability of oxygen in the water, but it does not show where it is coming from. A careful survey of the plant does show this, and serves as a basis for an intelligent and effective campaign to eliminate the source of needless destruction of equipment and impairment of safety.

The means for eliminating oxygen will take various forms depending upon its source. If it enters in solution in raw water, some form of deaëration must be used. If it is picked up by the water circulating around the plant, deaëration may be used, or the system may be modified to avoid the picking up of air en route. If air enters through leaks, the remedy is obvious.

The chemist has found the culprit. He has given the engineer a method for discovering the point and manner of his entrance into the water. The engineer's job is to stop those weak points or to apply an effective remedy. It is up to the engineer.

Water-Power Development and Flood Control

AT THE present time the floods on the lower Mississippi River are attracting a great deal of attention from all parts of the country. It is but natural that this occurrence should direct attention to why these floods occur, how to prevent them and why means have not been provided for their complete control before this time. The answer to the last question is, the control of this river is a problem of tremendous magnitude. For more than two hundred years efforts have been made to control these floods, but only within comparatively recent years has any degree of success been attained.

If the problem were easy, it would have been solved and forgotten long ago. A short distance below the mouth of the Ohio the flow of the Mississippi varies from about seventy thousand second-feet to over two million. To keep under control a flood of these proportions carried between alluvial banks, through a flat country for over one thousand miles, is no small task.

A natural question is, Why not control the floods before they get into the main river? On some of the smaller rivers in various parts of the country regulation has been obtained by the construction of storage reservoirs in conjunction with hydro-electric power developments. A complete development of the power resources on the tributaries of the Mississippi will undoubtedly assist in controlling the floods in the lower river. But those who have studied this problem most extensively do not believe that flow regulation and power development on the upper rivers is the solution of the problem. This, for the very good reason that the water that causes the heaviest floods does not come from the headwaters of the tributaries, but from the Ohio and Mississippi valleys, where the expense of constructing reservoirs would be prohibitive.

Furthermore, if reservoirs are constructed, are they to be for power purposes primarily or for flood control? Unfortunately, these two classes of service have different requirements. For flood control the object should be to dispose of the excess water as quickly as possible so that the reservoirs may be available for storage during periods when the river cannot carry the total flow, which may be only once in five or ten years. Reservoirs for power purposes are used to store the excess water that cannot be passed through the power plants at times of high water. It is possible to fill the reservoirs during a wet season preceding a flood. Under such a condition the reservoirs would be practically useless to assist in controlling the flood. In any river system it is possible to get practically the extremes of high and low water when reservoirs are used to regulate the flow as obtained before they were constructed. Reservoirs will in general produce a more constant flow than existed before they were built, but under extremes of drought and flood they may have little effect.

Water-power development has been tied up with many other interests, such as municipal water supply, navigation, irrigation and others, and all of these have retarded the power development to a greater or less degree. With these as a precedent it does not seem desirable to hang another appendix on water power, especially when there is a possibility of its having a detrimental rather than a constructive effect, and at the same time not accomplish the purpose intended.

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Eliminating Air Leaks in Boiler Settings

In our boiler plant, which contains several water-tube boilers that are baffled for three gas passages and fired with pulverized fuel, we had considerable trouble with air and dust leaks in the boiler settings.

Readings taken with an Orsat showed a drop of approximately 1½ per cent CO_2 between the top of the

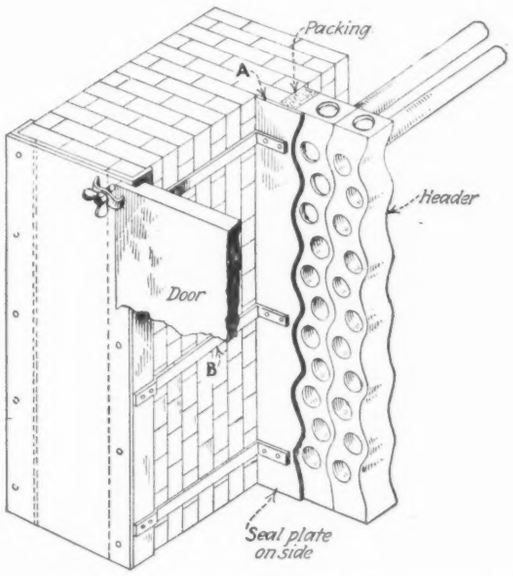


Fig. 1—Plate fastened to side wall and resting against header holds packing in place

second pass and the boiler outlet. An inspection was made of the rear headers, and it was found that the rope asbestos used in the joints between the end headers and the side walls was loosely held in place and in some spots had fallen out. It appeared that the movements of the headers and side walls caused by temperature changes, and the internal pressure created by the soot blowers when being operated, had forced this packing out. After the joints had been repacked with rope asbestos, the boiler was placed in service.

Further readings taken with the Orsat across the second and third passes showed that the drop in CO_2 of the gases was less than ½ per cent. Following the repair of the header packing CO_2 readings were taken daily, continuing for about three weeks, when it was again noticed that the CO_2 had dropped about 1½ per cent. The boiler was taken out of service, and when the rear header doors were removed, the same trouble was found at the joints between end headers and side walls. The failure of the packing to stay permanently in place, indicated that some secure support was needed to prevent its dislodgment. Whatever means were adopted, however, should not interfere with the movement of the headers caused by temperature changes.

It was decided to reinsert the asbestos rope packing and to use it as the principal means for sealing the joint. To obtain flexibility, asbestos cement and bitumastic gum were next troweled over the outer surface of the packing, in a layer from ¼ to ⅜ in. thick. Then a steel plate, *A* ⅛ in. thick and approximately 4 in. wide, was placed against the header to hold the packing in place as shown in the illustration. This plate extended the entire height of the headers and was cut on one side to conform to the outline of the sinuous headers. It is held in place by ⅛x1-in. strap brackets *B* bolted to the steel frame of the boiler casing.

This method of supporting the seal plates obviates any danger that might be encountered by obstructing the movement of side walls and headers and allows the plates to move freely with the side walls and yet prevent the dislodgment of the asbestos packing.

Similar plates were placed on the sides of the front headers as a safeguard against any air leakage into the first pass of the boiler. As a further precaution against

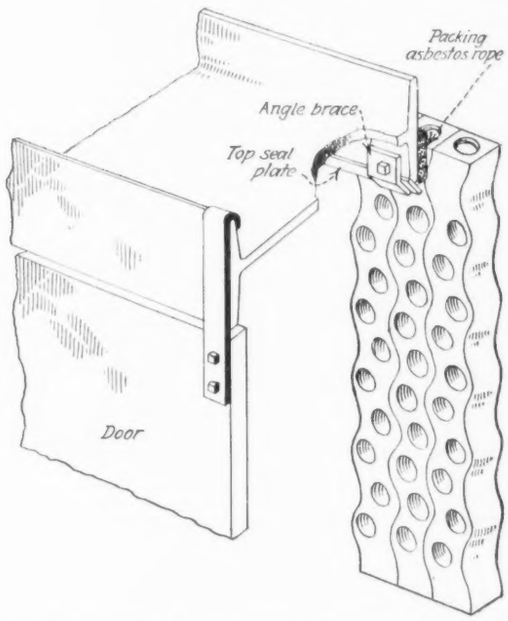


Fig. 2—How packing between I-beam and boiler header is held in place

dust and air leaks a strip ⅛x1 in. and running the full width of the boiler was placed at the top of front and rear headers. At this point, as shown in the drawing, an I-beam at the top of the headers was the only means of supporting the plate. Clips ⅛x1x3 in. were placed in position on the I-beam and the rope asbestos reinserted and used as the base of the joint. As on the side joint, layers of asbestos cement and bitumastic gum were troweled on and the plate placed in position. The clips

were then heated by an acetylene torch and bent to form an angle holding the plate in against the header and at the same time allowing it to move freely with the I-beam without undue pressure upon the header.

These plates, besides cutting down the air leakage into the furnace, prevent the dust from working out through the setting and into the boiler room.

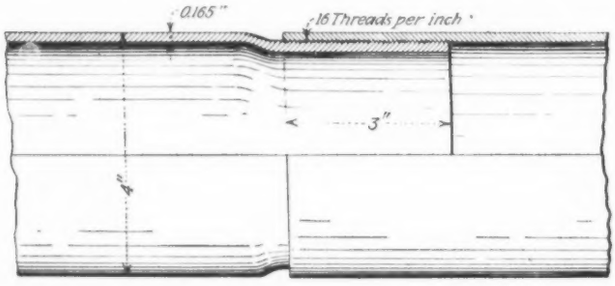
Orsat readings are taken daily as a check on the seal plates, and results have shown that the seals as now arranged are good for an indefinite period. The cost of installation of these plates is a minor question when compared to the saving in fuel and in the labor required to keep the boiler room clean and free from dust.

Holtwood, Pa. M. W. HORLEY, Boiler Engineer,
Pennsylvania Water & Power Co.

Installing Boiler Tubes in Two Pieces

In a plant where I was engineer there were three 3,000-sq.ft. horizontal water-tube boilers. In front of two of the boilers there was ample room for pulling and replacing tubes, but, in front of No. 1 boiler, a tank 7 ft. in diameter and 8 ft. high, was placed over the feed pump to act as a heater and receiver for the condensation of the heating system. Whether this tank was placed there before installing the boiler or after, no one seemed to know. The tank was in such a position that only the two vertical rows of tubes on the right side could be pulled and renewed. This fact was not apparent until several leaky tubes showed up near the center of the boiler. To take out the tubes was simple—they were cut in half; but to put in the new tubes presented a problem. It seemed to be a case of move the tank or the boiler. Then it was thought best to consult the boiler manufacturer, and he solved the problem by making each tube in two parts.

A batch of extra-heavy tubes with a joint in the middle was made up. The joint was made by swaging one-half of the tube a little smaller on one end. This small end was then threaded with a fine thread about 16 to the inch, and the end of the other half of the tube was



Screwed joint in 4-in. extra-heavy boiler tube

threaded internally, about three inches of thread being used.

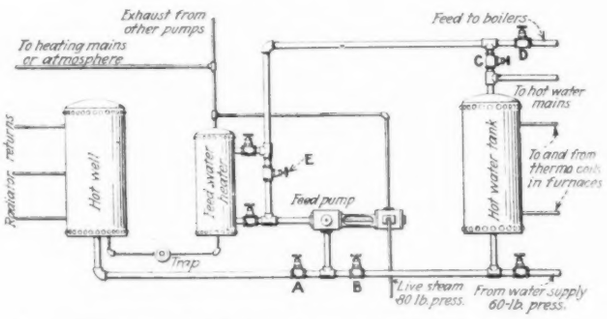
The work of installing the tubes was easy. One-half of the tube was pushed through the tube hole until about one foot was left sticking out in front of the boiler. The threads were then wiped clean and a thin mixture of white lead and linseed oil was put on; then the other half of the tube was screwed onto this. In making up the joints we used two Stillson wrenches, and only a moderate pressure on the wrenches was required to make a tight joint. In eight to ten years of operation none of these tubes has ever leaked at the joint.

Rosedale, L. I. JOSEPH O'BRIEN.

Meeting the Demand for Hot Water

While I was assistant engineer of a moderate-sized heating plant that supplied heat for a number of buildings and also pumped water for a small community, the hot-water system became inadequate. The plant was one of those "assembled" kind; that is, no thought had been given to the selection or installation of the equipment or to future growth.

As a result, when two more dormitories were finished and connected up, the hot-water system was unable to meet the demand placed upon it. The higher-ups in the office were always kicking about the "cold" hot



Arrangement of piping to permit use of feed-water heater for heating-service water

water, yet when an approach was made for equipment to meet the demand, that was another story. I thought it might interest *Power* readers to know how we overcame the trouble in a rather simple but practical way.

The hot-water producing equipment consisted of a 48-in. by 10-ft. tank and a thermo coil in each of the two 1,200-sq.ft. return-tubular boiler furnaces, with necessary valves, etc. It also had a feed-water heater three or four sizes too large and a feed pump of about the same proportions, together with other pumps and engines. Thus we had plenty of exhaust steam, in the summer time especially.

In our desperation one day the thought came to us, Why not use the feed-water heater for heating the hot-water supply, the heater being of the closed type? The accompanying sketch shows diagrammatically how this was done. The actual layout, of course, was somewhat different, but the circuits are the same. Only the more important valves are shown, however.

By studying the sketch, it will be apparent that by closing valve *A*, opening valve *B*, heater bypass *E* closed, opening valve *C* and closing valve *D*, the circuit is through the pump, heater and tank. By closing valve *C* and opening valve *D*, with either valve *A* or *B* open (but never together), the boilers may be fed. Other combinations are readily made as the occasion arises, such as making up a deficient hotwell level. Also, a boiler may be filled by the external water pressure either when the steam pressure is low enough or after a boiler has been cleaned.

After these changes were made, no further complaints were received about hot water, except that it was too hot. And the changes were made at practically no expense except for labor and a few fittings. One benefit brought about by the change was to provide use for almost all the exhaust steam in the summer time, when no heat was required, but hot water was demanded just the same. KENNETH R. GIDDINGS.

Billings, Mont.

Comments from Readers

Beware The New!

I was much interested in the editorial in the April 19 issue, "Beware the New!"

I wonder if the greater danger is in engineers and manufacturers adopting the new, or in sticking to the old. It is undoubtedly true that mistakes have been made by people of immature judgment jumping into something which they were not fully advised on and because of that making a mistake, but I think it safe to say that while one mistake of this kind is made, a thousand are made by people sticking to an old antiquated out of date machine or method, when a new one is at their hand and should be adopted.

I doubt if there is any best manufacturing method today that will be the best manufacturing method five years from now; I doubt if there is any best design today that will still be the best design five years from now, and I doubt very much if there is any company that can stand pat on its present machine or method and be safe in the next year. The road is strewn with the wrecks of people who have stopped growing and the wrecks of plants that tried to apply Nineteenth Century methods in the Twentieth Century.

There are any number of insurance policies to protect the company against the death of some valuable executive, and much of this insurance is carried. It is too bad there are not also insurance policies that companies can take out to insure them against the going to seed of their chief executive and the stopping of progress of the organization. I have seen few concerns myself that have ever permanently suffered from the death of an individual; I have seen hundreds of them, however, go broke because some man did not die or did not recognize the fact that his day had passed.

J. F. LINCOLN, Vice-President,
Cleveland, Ohio. The Lincoln Electric Co.

District Heating with Exhaust Steam—Why Not?

In the April 26 number of *Power*, page 640, Alfred Cochran has an article under the heading "District Heating with Exhaust Steam—Why Not?" in which he says that "district heating has not been touched so far as domestic needs are concerned." I should like to cite an example to the contrary.

The entire main street of Brookings, South Dakota, a city of about 4,000 people, is heated with exhaust steam from the municipal power plant.

Not only the business buildings, but all municipal buildings are heated, such as the city hall, the schools, the telephone building and the public library.

It is found that exhaust-steam heating is economical. Until a short time ago steam condensate meters had not been installed, heat having been furnished on a flat wall-area basis. This method was a thorn in the flesh of many of the Brookings people who believed that the city was losing money because of its loose methods. It is true that some users of city heat were unnecessarily careless in leaving windows open during cold weather. But meters have corrected that evil. Sometimes during extremely cold weather (the thermometer drops to 40 deg. below zero in that locality) live steam is furnished for heating, which is permissible provided it is confined to cold weather. Some of the taxpayers have protested against the use of live steam as a heating means, but it is easy to show that such protests are uncalled for so long as the use of live steam is not overdone.

Contrary to practice in most other cities in the United States at this time, the cost of steam heat from this municipally owned plant, instead of being increased, has been reduced from $1.10 per 1,000 lb. of condensation to $1. W. F. SCHAPHORST.

Newark, N. J.

"Accident Sense" in the Power Plant

I was much interested in the article by F. P. Terry, in the April 26 issue on "Accident Sense in the Power Plant." Now, most accidents can be avoided if reasonable precautions are taken. In this category can be placed bruises obtained in the routine work of the power plant, stepping on a board with a nail in it, being struck by falling objects, accidents resulting from lack of a guard around moving machinery, neglect of equipment, etc. Then again there are accidents that apparently no amount of precaution can prevent. The following is a typical illustration of how simply accidents can happen.

A 20x42-in. slow-speed engine, one of those old-fashioned kind with the crank not inclosed, was in operation. The crankpin was oiled with a grease cup and the rest of the parts with oil. On one occasion, while filling the oil cups on the main bearing and enjoying his corn-cob at the same time, the engineer, absentmindedly, placed his pipe on the main bearing and went around to the crank. Attempting to reclaim his pipe by reaching over the crank instead of going around, he was drawn under the crank with fatal results. This accident occurred in the plant where I am at present employed. The old adage of using one's head and saving the feet did not apply in that case. Now, how can an accident like that be avoided as long as a workman will take a chance?

A Scotch marine boiler on board a ship developed a leak at one of the rivets over the fire. Upon arrival in port the boiler was cooled off, but through neglect the water was left in the boiler. The engineer went into the firebox with calking tools and upon hitting the rivet with the hammer and tool, it came out allowing hot water to pour out and fatally scald the engineer before he could escape. This accident occurred recently to one of my engineer's relatives.

In a certain plant a 1,500-sq.ft. boiler furnishes steam at night for process work. On one occasion the night fireman had just covered the fire and was shutting the firebox door when the gage glass broke, causing a stream of water and steam to strike an electric light

globe, breaking it and throwing the plant into darkness. The stream of steam and water had caused a short-circuit and the fuse had blown. The rushing steam and water soon had the boiler room full of vapor, and by the time the fireman had found a lantern and located a good fuse and collected his senses sufficiently to shut off the water column, the steam pressure was low and so was the water. As to "accident sense" he did not have any. What was the result? When he had got the room clear of steam and placed a new gage glass in the water column, he proceeded immediately to fill the boiler with cold water from the city main and at the same time start a hot fire in order to get steam up as quickly as possible. Of course, everyone who is versed in the operation of boilers knows what was likely to happen. When the chief engineer reached the plant and had heard the fireman's story, he at once hastened to determine what damage had been done to the boiler. The result was evident—the combustion chamber was a miniature fountain as viewed from the rear clean-out door, the fusible plug was gone and several tubes had to be removed.

Bayonne, N. J. THOMAS W. GRAY.

What Must Be Done To Overcome High Wages and Fuel Costs?

Although the cost of fuel and labor is practically twice what it was fifteen years ago, the present cost of heat and power is about the same. This is primarily true in our larger central stations, but does not hold in the average industrial plant. Most large central stations use every means of automatic control, instruments to indicate conditions and equipment to harmonize performances to as near the theoretical ratio as are possible to maintain.

The equipment and apparatus necessary to bring any plant up to a high standard of efficiency are varied and many. Some engineers ask for equipment arbitrarily; sometimes these requests are granted, but generally they are not. When a request for equipment is refused, some engineers lose heart and think the managers are unreasonable, but as a general rule this is not true. The relative advantages of the equipment or apparatus has not been advanced or put up to the managers in a proper or convincing form.

The position of the representative for such equipment and apparatus is an important one. The average salesman apparently just comes in to talk things over, to see if the plant engineer has thought of anything he wants to buy. Few have any really definite proposition to make, but they may tell of hundreds of plants where their equipment has done wonders, but never a word as to how their apparatus will benefit your particular plant.

Most engineers and managers feel that there is really a need of heat and power conservation apparatus, but few representatives make any real effort to interest them by presenting some fundamental reasons why their particular apparatus will benefit the plant and pay interest on the investment. Not infrequently the mistake is made of selecting the wrong equipment or of applying the right apparatus to the wrong equipment. It follows, therefore, that gradually two classes of agents have developed: First, the representative who is purely an order taker and, second, the representative who is capable of advising the plant engineer as to the adaptability of the apparatus, so that the latter can lay before the plant manager definite plans and figures on savings as well as increased production and general benefit to the purchaser.

The application of boiler- and engine-room apparatus and equipment will generally influence the results obtained outside of the boiler and engine room, by increasing commodity production and preventing shutdowns or loss of production by low steam pressure, low voltage or other causes.

When an engineer goes before the plant manager with a half-baked proposition, he must expect to get turned down. The managers want to know four things: (1) What the equipment proposed will cost; (2) what the plant will reasonably and certainly be expected to produce; (3) what it is costing not to do it; (4) that the engineer positively and certainly can carry it to a successful conclusion. Omit any of these points or leave any reasonable doubt on any of them, and you are sure to be denied the request.

The cost is not hard to determine, but it is not always easy to lay down charts and specific tabulated figures to show what the plan is expected to produce. What it will cost not to approve purchasing the equipment is usually one of the strongest points to stress. The services of the representative are invaluable in the compiling of the data relative to efficiencies and adaptability of the equipment to produce certain results along with the ability of the manufacturer to install and instruct the operators in the handling of the apparatus.

The danger of selecting inappropriate apparatus for saving heat and power is realized by both engineers and plant managers. In any case the installation of such equipment is to reduce the costs of producing heat and power, increase commodity production and prevent loss of production and time by preventing shutdowns. In any case whether as a current expense or an investment such equipment or apparatus installation is expected to show a profit. Slowly but surely representatives and manufacturers of power-plant equipment are realizing the necessity of complete service to the engineer in every phase of compiling data, specifications and erection of the apparatus along with complete engineering service.

Largely through the increasing experience of representatives and the efficiency of the manufacturer's engineering departments the percentage of failures of equipment and hazard in selection of apparatus is being steadily reduced. The representative must know to a penny the cost of the apparatus installed ready for operation. He must be ready to supply the engineer with sufficient data to compile figures and charts if necessary and even supply engineering data to carry the installation to a successful conclusion.

New York City. F. G. PARKER.

Increase in Cylinder-Oil Consumption Due To Boiler Compound Entrained in Steam

The inquiry of W. E. Foley in the April 26 issue, as to the increase in cylinder-oil consumption due to boiler compound contained in steam, brings to mind the troubles I encountered some years ago with entrained compound. The first trouble I had was in connection with a large Corliss engine on which the valves began to groan, apparently owing to a shortage of lubrication.

An examination of the lubricators showed the usual amount of oil being fed. The hand oil pump was used and the valves stopped groaning for a short time, but when the extra supply of oil was used up the groaning

recurred. The lubricator connections were examined and cleaned, without making any change in the operation of the engine. Only by increasing the amount of oil to the cylinders, could relief for the valves be obtained. While endeavoring to detect the cause of the groaning on the engine, an important pressure-reducing valve began to give trouble, and when it was dismantled a distinct roughness was found on the moving parts which tended to keep the valve from operating properly. A subsequent examination of the large engine also disclosed a roughness on the valves which we concluded was caused from some impurities in the steam, as it had been necessary to feed about double the normal amount of cylinder oil.

Upon blowing some of the steam through a strainer, made up of cheesecloth and brass gauze, the cause of the trouble was apparent, for the cloth and gauze mesh were coated with a sediment or coarse silt.

The water in both boilers was changed at once, as we decided that the trouble was caused by a new boiler compound that we had been trying out, which the salesman had said would do what no other compound had ever done for us before, and he was apparently telling the *truth*.

Changing the water in the boilers soon had us back to normal operating conditions and the new compound on its way to the ash pile. I might add that our steam-flow meters were also affected by this compound collecting in the connections. O. F. DUBRUIEL.

St. Paul, Minn.

What About the Water Level?

After reading the article "What About the Water Level?" in the April 26 issue, I am inclined to think that the author has "spoofed" us. It does not seem possible that a steel cylinder, partly filled with water and heated on its under side (or the water heated in connecting tubes and delivered to the cylinder by convection), otherwise known as a steam boiler, subject to varying loads, varying draft, varying feed-water temperatures and varying percentages of water impurities could be so sensitive to a slight increase in the height of the water level as is assumed in that article. It seems that the steam boiler has taken one of the prerogatives of the prima donna—temperament.

In the first paragraph of the article is this: "If the water level in the boiler is one-half inch higher than the level observed in the glass, it can cause no end of trouble and great loss of economy." I should like to have that statement explained and, if possible, a quantitative demonstration offered. Just how does a half-inch variation in the water level influence, operation so profoundly? What is this "no end of trouble"? And what is the "great loss of economy"? And how is it effected? In a later paragraph is this; ". . . figured and found the liberating area to be just about enough. . ." What is enough liberating area, and how is it figured? And just what constitutes liberating area?

Let us see to what extent a rising water level will effect "liberating area." According to the article quoted, the author "figured the area with a rise of 1 in. in the drum, and then 'I beheld a great light' on the priming problem that was giving me gray hairs." The implication is that the rise of 1 in. made such a great change in the liberating surface as to cause the boiler to prime badly. Raising the water level in a 36-in. boiler drum 1 in. above the center line will decrease the width of the level less than $\frac{1}{16}$ in. Raising it 6 in. will reduce the width only 2 in., or 5½ per cent. In order to reduce the surface one-half, the level would have to rise 15½ in., or to about 2½ in. of the top of the drum, which would practically obliterate the steam space. It strikes me that priming must be charged to something else than lack of liberating surface (using the term "liberating surface" in the commonly accepted manner) because it would be an unusual type of boiler that would be seriously lacking in this respect.

There is not a piece of apparatus in the realm of mechanical engineering about which there are so many and so divergent opinions as the steam boiler. And I don't know of a piece of apparatus so badly in need of "debunking." (Perhaps this statement should be applied to the bunk venders and not to the boiler). The boiler seems to be like the automobile—the make you happen to be driving is the best ever. Which reminds us that "There are four-and-twenty ways of writing tribal lays, and every bloomin' one of 'em is right." The alleged great superiority of the one type over the other has its genesis in salesmanship, not engineering. One can be assured that when an effect is accomplished by many and various means, then the underlying principles are comparatively simple.

There are many terms current in engineering that have descended from an obscure past and that are unquestioningly accepted as fact. These are the dogma of the profession. One of these is the necessity of ample "liberating surface." Liberating surface, as ordinarily understood, is the area of the surface of the water in a steam boiler. If a large area is so potent in preventing priming, then the return-tubular boiler should be the least susceptible to this fault as it has a much greater water surface than a water-tube boiler of the same capacity. Is the return-tubular boiler free from the priming fault?

In discussions of priming one is frequently met by the impression that the water leaves the boiler in large bodies, or "slugs." If this were the case, the moisture content of the stream would not be in the order of a few per cent, but would measure in the hundreds of per cent of boiler capacity—the water would outweigh the steam. Steam carrying 10 per cent moisture can be regarded as very wet. Ten per cent moisture in steam at 150-lb. gage would be represented by a little more than half an ounce of water per cubic foot of steam—less than $\frac{1}{10}$ of 1 per cent of the volume.

The rate at which the boiler is driven and the amount of impurities in the water seem to be the principal factors contributing to priming. Oil is probably the worst of the impurities. Anyone who has watched the froth formed with a small quantity of oil in the water used in the flotation process of mineral separation will have an idea of the foaming and priming possibilities of a small amount of oil in the boiler feed water.

There seems to be a greater tendency to priming in oil-fired than in coal-fired boilers. The probable explanation is that the maximum temperature occurs in lanes, causing a few tubes to evaporate water at much higher than the average rate, resulting in rapid upward movement of the steam through the tubes which, breaking through the surface of the water in the drum, produces a spray that is carried out of the boiler.

Reducing boiler capacity in order to prevent priming is backtracking, and in order to meet sudden demands for steam, the water should be carried as high as practicable. Should priming occur with clean feed water, then a separator, internal or external, should be used.

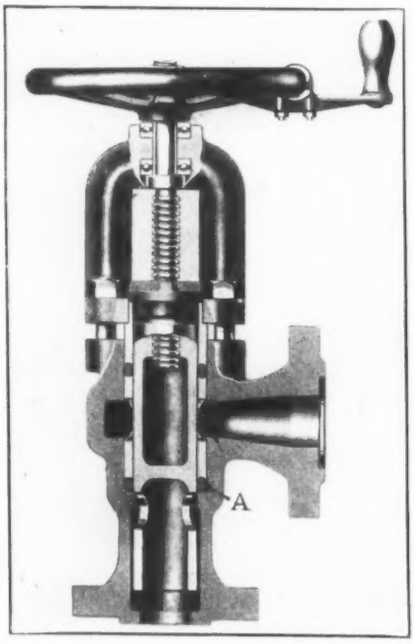
Los Angeles, Calif. C. O. SANDSTROM.

New and Improved Equipment

Yarway Type C Blowoff Valve

The line of seatless blowoff valves manufactured by the Yarnall-Waring Co., Philadelphia, Pa., has been extended to include the type *C*, illustrated herewith for pressures up to 900 lb.

This type differs from the type *B* described in the April 21, 1925, issue, in that the lower packing *A* is set deeper in the body below the inlet with a correspondingly longer plunger, so that at no time during the cycle of operation or blowdown is the packing exposed to the flow. Other features of the new



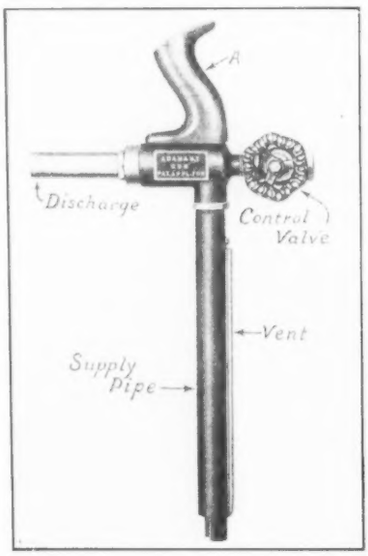
Cut-away view of type C valve

valve are the use of a one-piece plunger and a double ball bearing in the yoke to absorb the thrust of the spindle in either direction.

The valve is made in electric furnace steel with bronze, nickel alloy or monel-metal trimmings in both angle and straightway types.

Botfield "Adamant" Cement Gun

To facilitate the coating or lining of new or old furnace walls with "Adamant" cement or other prepared refractory, the Botfield Refractories Co., Philadelphia, Pa., has brought out the gun shown in the illustration. It is designed to operate with compressed air at 50 to 80 lb. pressure and by reason of its light weight, which is approximately 4 lb., and the accessibility of the regulating valve, the operation is readily performed by one man. Steam can be used in place of compressed air if necessary, but for best results the use of air is recommended.



Portable cement gun

The handle *A* is of wood and is so shaped that the gun is readily directed at any part of the wall.

In operation, the supply or suction pipe is placed in the cement or pre-mixed refractory, then the air is turned on and regulated by the control valve to give the desired flow.

To prevent plugging of the suction a small vent pipe, open at the upper end and passing through the supply pipe close to the bottom, is added. The bottom of the supply pipe is cut away so that the flow is not restricted should the gun be rested on the bottom of the container from which the cement is being drawn.

Aldrich Double-Acting Pump with Porcelain Plunger

A recent addition to the line of pumps manufactured by the Aldrich Pump Co., Allentown, Pa., is the

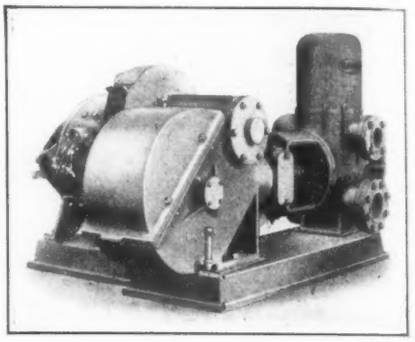


Fig. 1—General view of pump

horizontal double-acting plunger pump illustrated herewith. Fig. 1 shows a general view of the pump and Fig. 2 shows the constructional details and driving arrangement.

Although designed primarily for mine service, the pump is equally adaptable to various uses in the industrial field. It is motor-driven through a train of spur gears and is arranged for self oiling on the power end. The

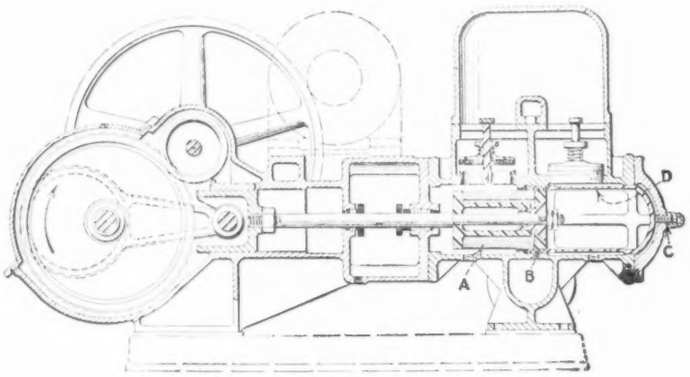


Fig. 2—Cross-section of pump showing details of construction

porcelain plunger *A*, which is held between acid resisting heads, forms a separate unit from the plunger rod. The packing *B* at the center of the barrel is held in place and adjusted by means of the screw *C* and the gland or circular sleeve *D*. The valves are of bronze with rubber facings. The pump is made in three sizes, with capacities of 50, 100 and 150 gal. per min. with a maximum working lift of 300 feet.

C. & G. Cooper Build M.A.N. Diesels

The C. & G. Cooper Co., Mt. Vernon, Ohio, has completed three 150-hp. three-cylinder solid-injection Diesels for the Standard Oil Company of New Jersey. This type of engine is manufactured under a license from the M.A.N. Co. of Germany and has a cylinder bore of 12 in. and a stroke of 18 in., giving approximately 50 hp. per cylinder.

The engine operates on the single-acting, four-stroke cycle; the compression of 400 lb. supplies a temperature more than sufficient to ignite the fuel, even when the engine is cold. Without previous heating from ignition cartridges or hot bulbs, the engine can be placed in service immediately from an entirely cold start.

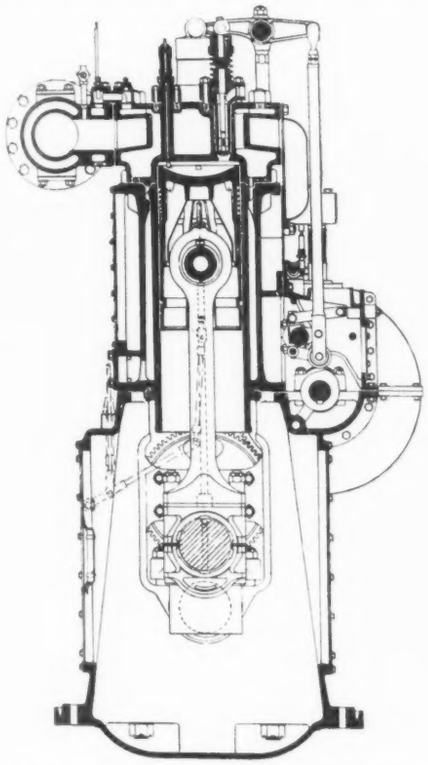


Fig. 1—Cross-section of Cooper-Diesel

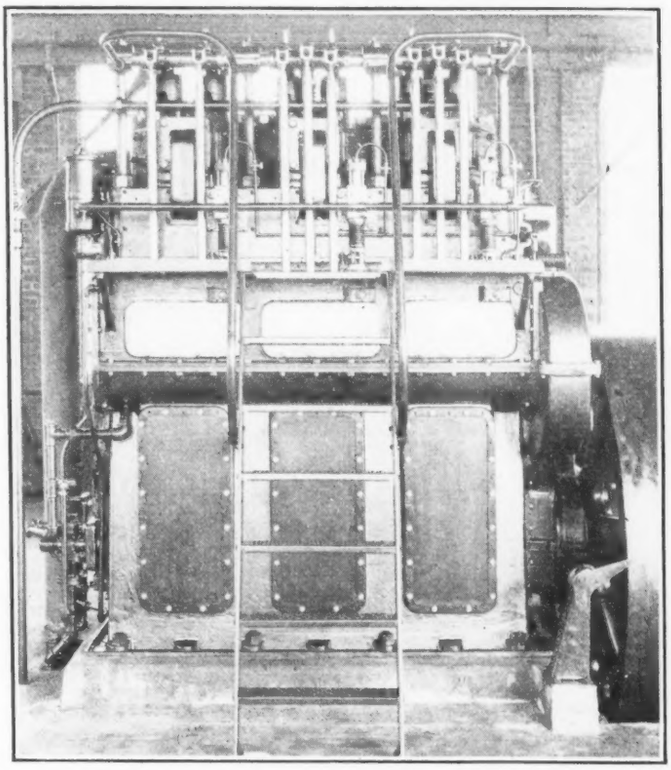


Fig. 2—150-horsepower Cooper-Diesel on test

The fuel is injected into the cylinder through two spray nozzles shortly before the piston reaches the top dead center by a cam-driven pump. Each cylinder has its own fuel pump, driven direct from the camshaft. The two injection nozzles and the high-pressure piping which connects them to the fuel pump can be dismantled as a unit, by loosening two screws. They are located one on each cylinder side, so that the oil sprays from each one at an angle with the cylinder axis. This tends to mix the atomized oil thoroughly with the air.

The governor mechanism is built as a unit with its drive and is located on the flywheel end of the engine, in an extension of the camshaft gear case. The amount of the fuel entering the cylinder is controlled by the effective stroke of the fuel pump, which is in turn controlled by the point of "cutoff" of the small bypass valve in the pump.

All the fuel discharge from the pump plunger goes directly into the cylinder, until this bypass valve opens. At this point there is a sharp cutoff and the remaining part of the stroke merely bypasses the oil into the pump suction. The point of opening of the bypass is controlled by an eccentric shaft, operated by the governor; the shaft also carries a hand control and an indicator which shows at all times the approximate percentage of full load.

The fuel supply may be either from an overhead tank or from below the engine level. In the latter case the engine is provided with a small rotary pump, which delivers the fuel oil into the main cylinder pumps. Force-feed lubrication is used throughout, the pressure being supplied by a rotary positive displacement pump geared to the mainshaft.

The cylinder block is made in one casting for three cylinders and two castings for six cylinders, and is fastened to the bedplate by means of long steel tie bolts, which reach from the top ends of the cylinders to below the mainshaft bearings in the bedplate. The cylinder block also serves as a water jacket. Each cylinder has its individual cylinder head, which in turn contains one suction and one exhaust valve and two fuel-injection nozzles.

The bedplate is of an oil-tight box frame construction, cast in one piece. It carries the main bearings, camshaft casing and camshaft bearings. There is a main bearing on each side of each crank, and the bed is common to both right and left-hand engines, each end being identical.

The lubrication, which is of the forced type, provides for the circulation of oil through all bearings inside the crankcase. The bottom of the bedplate forms a drain tank from which the oil is pumped through a filter and cooler.

Lincoln Non-Splashing Welding Rods

A new line of dipped welding rods has been developed by the Lincoln Electric Co., Cleveland, Ohio. This steel rod is the result of several years' study in the company's research laboratories and will be known as the "Stable-Arc" welding rod. With this new rod it is possible to go to considerably larger diameters than has been customary for metal electrode welding and is being carried in all sizes up to $\frac{1}{2}$-inch.

It is claimed that this rod permits of much higher currents than have been used heretofore, with the resulting greater speed; current densities up to 15,000 amperes per square inch can be used. As labor is by far the greatest factor in welding costs, increased speed means a substantial decrease in welding cost. The greater heat gives not only greater speed and less cost, but also better penetration and a much smoother finished bead. In addition the greater heat obtainable by the higher currents results in an annealing action which increases the ductility of the weld and gives a greater elongation.

The decrease in the "splutter" of the arc should give less spattered metal, and therefore more actual metal should be deposited per pound of rod. The higher currents, it is claimed, give a remarkably clean finished weld and on heavy welds of more than one layer very little brushing or cleaning is necessary between beads.

Fatigue of Welds*

AT THE annual meeting of the American Welding Society a symposium was given of the research activities in the field of welding during the last three years. Of particular interest to engineers in the field of power is the paper on the "Fatigue of Welds," by R. R. Moore[1]. Although the research work was intended to apply to the construction of the fuselage of airplanes, the results may be taken as an indication of what may be expected in other fields of welding.

The author reports fatigue tests on samples of 1-in. and ½-in. diameter steel tubes of ⅛-in. wall, welded by gas, metal arc and atomic hydrogen processes. Various kinds of filler rod were used, including Norway iron, low-carbon steel, vanadium steel, chromium molybdenum steel, and Kote steel. Also, test specimens were made from deposits of Norway iron and Kote steel filler rods by all three welding methods.

THE possibility of low fatigue endurance has been largely discussed, but little work has been done to determine the facts. This paper is a timely one, because of the present consideration being given to welding pipe joints, as well as general welding in and about the power house.

The fatigue tests were made on the rotating-beam type machine shown in Fig. 1. This machine, developed for these tests by the author, permits smoother operation and the use of short specimens, which made the tests on the deposited samples possible. In this machine the specimens are subjected to stresses that pass through a complete cycle from tension to compression of the same magnitude.

The endurance limit was determined by finding sufficient points on the endurance curve, Fig. 2, to locate the stress at which the curve flattens or becomes parallel to the axis representing the number of stress reversals. The stresses were computed by the common beam formula and were based on the diameter and gage of the tube and not on the size of the deposited metal in the welds.

Results of Tests

With one exception the tensile strength of all the welded tubes was found to lie between the limit of 50,500 and 62,500 lb. per sq.in. As all failures occurred outside the weld, it cannot be shown that any of the filler rods have an advantage in tensile strength. The location of the fracture 1 in. from the weld is claimed to be due to softening of the tube by the heat of the welding torch and the increased cross-section at the weld.

The highest endurance limit obtained on the gas-welded 1-in. diameter tubes was 16,000 lb. per sq.in. for those welded with low-carbon steel filler rods. The failure did not occur in the weld, but in the tube about ⅝ in. on either side of the weld. Tubes welded with Norway iron filler rod in all cases failed in the middle of the weld and gave an endurance limit of 13,000 lb. per sq.in. The specimens welded with chromium molybdenum filler rod gave the very low endurance limit of 8,000 lb. per sq.in. and failed through the middle of the weld. This was found not to be due to the type of filler rod, but to poor welding, as evidenced by lack of penetration of the weld.

Of particular importance is the fact that on static tensile test, this weld was as good as the other welds, and the fracture did not occur in the weld, showing that the tensile test was not successful in detecting the deficiency. The value of the fatigue test is forcibly demonstrated here. The ½-in. diameter tube welded with Norway iron filler rod showed an endurance limit of 22,000 lb. per sq.in., which is an increase of 70 per cent above the endurance limit of the 1-in. diameter tubes welded in the same manner. This increase is believed to be due to the fact that smaller specimens can be welded rapidly and kept at a more uniform heat, thus improving the structure.

Of particular interest are the results obtained from sample bars made by depositing Norway iron filler rod with the gas torch. The tensile strength obtained was 50,500 lb. per sq.in. with 26 per cent elongation. The fatigue test resulted in the relatively high endurance limit of 24,000 lb. per sq.in., which is 48 per cent of the total strength. This endurance ratio is exceeded by only a few steels.

It is better than the endurance limit

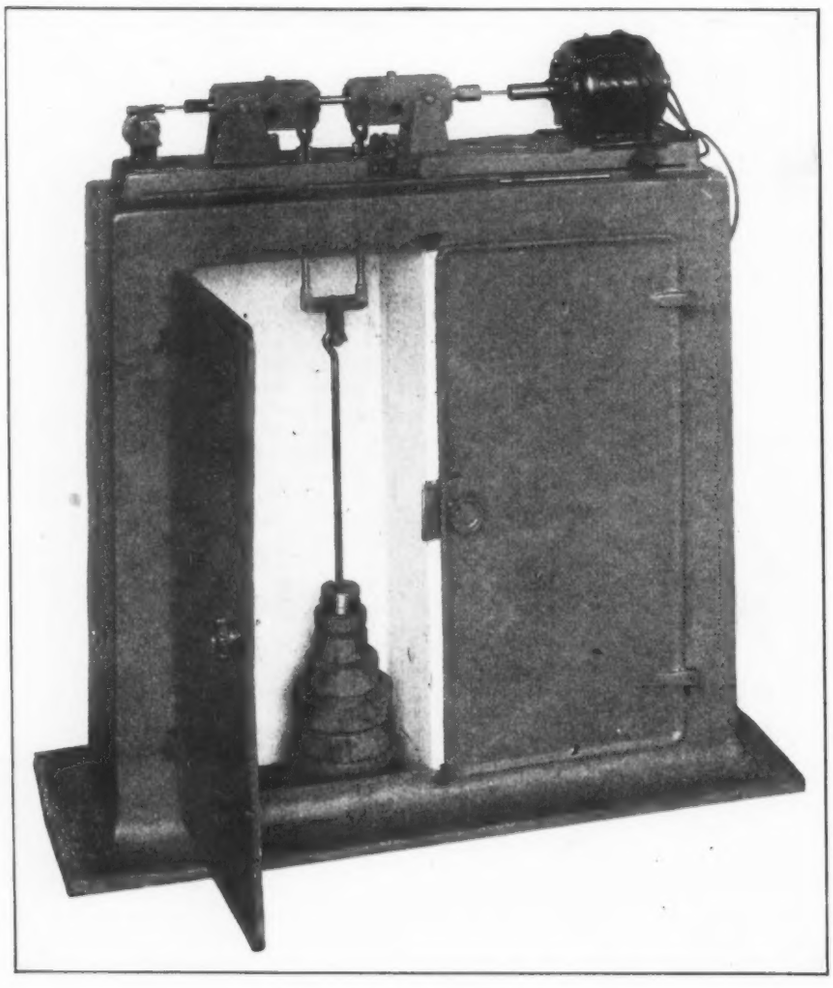


Fig. 1—Fatigue testing machine

*Presented at the annual meeting of the A. W. S., April, 1927.

[1]Chief, Physical Testing Br., Air Corp., McCook Field.

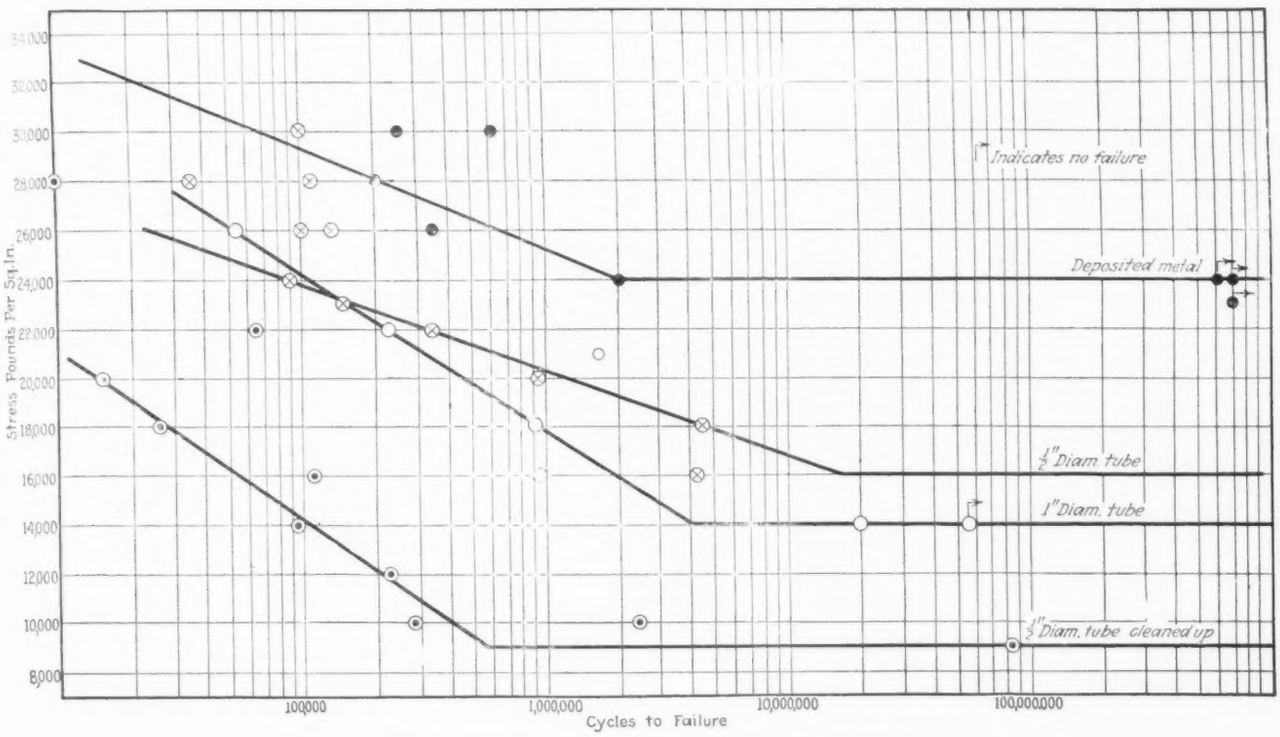


Fig. 2—Endurance curves on arc welded specimens

found on any of the welded tubes, and would indicate that the process of depositing the metal by gas does not have any detrimental effect on its resistance to repeated stresses.

Arc Welding

The test on the tubes welded by the arc method gave practically the same results as the gas-welded tubes. The tension fractures occurred in the tube, while the fatigue fractures occurred at the edge of the weld or through the weld. The ½-in. diameter tubes gave an endurance limit of not better than 16,000 lb. per sq.in., which is somewhat lower than obtained with gas welding. A ½-in. diameter tube, when the weld was cleaned up, gave the very low endurance limit of 9,000 lb. per sq.in. This low endurance stress was traced to poor fusion, and an examination of the fatigue fracture showed that it occurred at the weld in the fusion zone. There was very poor fusion between the tube and the weld, and many blow holes existed.

In the welds of all the arc-welded ½-in. "cleaned-up tubes" were found spots where there had been no bond, and in one case as much as 30 per cent of the cross-section of the tube showed no penetration. Here again the fatigue test showed defects not found by a tension test. The specimens made from the metal deposited by the arc process gave a tensile strength of 62,500 lb. per sq.in., but an elongation of only 1.5 per cent. The endurance limit was found to be 24,000 per sq.in., or the same as for the gas weld. However, its ratio to the tensile strength is only 38 per cent.

The third method of welding investigated was the atomic hydrogen process, the principle of which is to prevent the formation of oxide and nitride by welding in a flame of atomic hydrogen. The filler rod used was made from strips of the tube itself. These welds gave a tensile strength of 50,400 lb. per sq.in., which is less than any of the other 1-in. diameter tubes. The endurance limit was found to be 16,000 lb. per sq.in., and when the weld was cleaned up the endurance limit rose to 18,000 lb. per sq.in. The tension test failure occurred 1¼ in. from the weld, while the fatigue test failure occurred usually about ¼ in. from the weld. It would appear that this method of welding evidently softens the tube more than any other welding process.

In conclusion the author points out that poor fusion has a drastic effect upon the resistance of the weld to repeated stresses and may not be detected by tension test, but is by fatigue test. Long-time fatigue tests show that the deposited metal has a definite endurance limit just as found in steels. Although the tensile efficiency of the welded tubes was better than 75 per cent, the fatigue strength was as low as 13 per cent and never higher than 35 per cent of the tensile strength of the weld.

Water Absorbs Heat Only Slowly by Conduction.—Convection by movement of currents is necessary to obtain rapid heat absorption. Any portion of a boiler in which there is poor circulation is inefficient steam generating space. Circulation is important also for disengagement of steam. As soon as steam bubbles are formed, they should be swept from the heating surfaces. When the bubbles remain adhering to the hot plates, the heat of the fire is not promptly transmitted and there is overheating of the boiler material. This is a common cause for burning of vertical tubes, water-legs and furnace sheets.

Distribution of Ash-Forming Constituents in Coal

The ash-forming constituents of coal may be roughly classified as inherent impurities and extraneous impurities, according to W. A. Selvig, chief chemist, Bureau of Mines, and W. L. Gardner, research fellow, Carnegie Institute of Technology, in a recently issued bulletin. The former are mixed more or less intimately with the coal substances and are derived either from the original coal-forming material or from external sources such as sedimentation and precipitation while the vegetal coal-forming plant remains accumulated. The latter are present in the coal bed as partings, bands, or nodules of pyrite, slate, shale, calcite, bone, etc. These are formed either during the laying down of the coal bed or subsequently. Fragments of roof and floor which became mechanically mixed with the coal in the process of mining also contribute to the extraneous impurities.

By carefully burning a lump of coal in a muffle furnace, an ash skeleton may be obtained which, if examined, will usually show that the mineral matter is not uniformly distributed through the coal mass. Investigation of a number of British coals has shown this to be the case; also that coal may break up on handling or crushing, into fragments that differ considerably in percentage and composition of ash.

Inherent impurities, which consist principally of siliceous and argillaceous material, have a high fusing temperature; but if they also contain considerable quantities of calcite, gypsum or pyrite, they are likely to have a low fusing temperature, as the ash then contains well-mixed and finely divided constituents that readily combine to form a low melting slag.

Distillation Products of Coal

THIS abstract of Professor Christie's report for the Prime Movers Committee of the N.E.L.A. indicates the present status of this important development in the field of heat generation.

THE 1926-27 serial report of the Prime Movers Committee on "Distillation Products of Coal" indicates clearly the increasing interest being taken in coal carbonization. The material and data making up this report have been the work of the Subcommittee on Distillation Products of Coal, of which Prof. A. G. Christie is chairman.

Low-Temperature Carbonization

It is significant that two large public utilities are investigating the low-temperature carbonization of coal. A statement by C. F. Hirshfeld describes the work being done by the Detroit Edison Co. on a new process suggested by Harold Stevens. The preliminary experiments on a one-ton retort have given such promising results that a 24-ton retort is now being designed for the purpose of testing the process on a commercial scale. The interesting features of the new process are the use of electric energy in such a way as to level out the load curve of the generating station and the fact that none of the apparatus is subjected to high temperatures so that it should have long life and low maintenance cost.

The tar and oil yields, in both quantity and quality, are reported as about what is commonly expected from low-temperature processes. The gas yield totals about 3,000 B.t.u. per lb. of coal. The coke is firm, of good structure and more nearly resembles coke from a high-temperature carbonization process.

The status of the McEwan-Runge installation at the Lakeside Station of the Milwaukee Electric Railway & Light Co. is reported in a statement by Dr. W. Runge. Difficulty was at first experienced in obtaining an outside gas supply for starting the process, and only a limited number of runs have been made. The coke obtained is reported as soft and friable, but somewhat coarser than desired for use in the pulverized-coal furnaces of the Lakeside Station.

A statement by Prof. Alfred H. White discusses the results of experiments performed at the University of Michigan, in which crushed coal was dropped through heated tubes varying in length from 27 to 84 inches. Crushed coal as coarse as 20 to 35 mesh when dropped through these tubes, which had been heated to between 1,750 and 1,850 deg. F., was found to carbonize in the short time required to fall through the tube, yielding as much gas as would be obtained in ordinary gas-works practice. The fuel product is described as being so porous as to be almost bubbles and well adapted for pulverized fuel. Professor White presents in his statement the several differences between his process and the McEwan-Runge process. This new process has not as yet passed the laboratory experimental stage.

The Carbocite process, invented by C. B. Wisner, is now entering the commercial stage with a plant having a daily capacity of 1,000 tons of raw coal scheduled to start operation early this year.

The process is carried on in two adapted types of rotary cement kilns operating in tandem. In the first rotary the raw coal is pretreated or "Thermodized" and then discharged through a gastight feeder into the second rotary, where the carbonizing process is finished.

The coke product of this process takes the form of balls varying in size from 3 in. to ¼ in. in diameter. These balls, containing from 10 to 12 per cent volatile, are of suitable strength and density to compete with anthracite as a domestic fuel.

Only sufficient gas is produced during carbonization to provide fuel for the entire process. The tar-oil yield is about the average for low-temperature carbonization processes.

There are only two salable products obtained from this process, coke balls and tar oil. The sale of these must pay for the cost of the process and a fair return on the money invested.

The important feature of the Carbocite process is the pretreatment which is carried on in an oxidizing atmosphere. The purpose of the pretreatment is to restrict the swelling and agglutinizing properties of the coal to the extent necessary to form the coke balls.

Commercial Operation

A discussion of the results obtained from the commercial operation of the Maclaurin process at Glasgow is given by Blair, Campbell & McLean, Ltd. The yields of gas, dry oil and smokeless fuel per ton are tabulated in comparison with the yields guaranteed. The gas and fuel yields are greater than guaranteed, while the oil yield is less. The power required to operate the plant of four producers is given as 24.2 kw. and the number of men required for operation is 14 per 24 hours.

The chief difficulty experienced is said to have been caused by the segregation of raw coal fines, which caused plugging or blocking in the producer. This difficulty interfered with the continuity of operation and also affected the quality of the fuel product, and is now claimed to have been remedied. Statements by English and American engineers indicate that this process is not yet recognized as a commercial success.

A comprehensive review of the developments in the field of low-temperature carbonization is presented by A. C. Fieldner, of the Bureau of Mines. His opinion of the present status of low-temperature carbonization is that "No low-temperature carbonization plant anywhere in the world (excepting certain brown-coal plants in Germany) can yet be said to be in successful commercial operation; nor can it be said that success is much nearer than a year ago. Nevertheless, progress has been made in a better understanding of the great importance of the physical and chemical properties of the coal to be carbonized in relation to the process and retort design and in particular of the coking and softening properties of the coal when subjected to heat."

The operating features and results of processes both in America and Europe are discussed. The American processes reported, which have as their purpose the production of smokeless domestic fuel, are: The McIntire process of the Consolidation Coal Products Co., the Greene-Laucks process of the Old Ben Coal Corp. and the Parr process at the University of Illinois. Two processes discussed whose purpose is the precarbonization of power-plant fuel are the McEwan-Runge process of the International Combustion Engineering Co. and the Piron Caracristi process at the Ford Motor Co. which is now reported to have been dismantled.

The large-scale English processes reported are the Parker, the Maclaurin, the Sutcliffe-Evans, the Laing Nielsen, and the Merz and McLellan. Progress in the development of commercial and experimental processes in England has been greatly hampered by the coal strikes, and therefore there is little of major interest reported.

In Germany the low-temperature carbonization of brown coal and lignite has received the greatest attention. With the exception of the Saleri retort all the German processes mentioned in A. C. Feildner's statement are based on internal heating by hot gases of combustion. Two of the processes, the Julius Pintsch and the Hanl, are designed for operation in conjunction with stoker-fired boilers. The Dobbelstein process is reported as being the only retort in Germany producing smokeless domestic lump fuel.

Contributions to Theory

Dr. S. W. Parr, who has been making fundamental scientific studies on coal at the University of Illinois, finds that the absorption of oxygen during coal

storage or preliminary heating in retorts seriously lessens the coking properties of the coal, tending to make soft weak coke. The importance of this finding is realized in the Carbocite process, in which the swelling and agglutinizing properties of certain coals are restricted by heating in an oxidizing atmosphere. In heating certain other coals, however, oxygen must be excluded and gases formed during preliminary heating removed in order to retain the coking properties of the coal. This latter procedure is followed in the Parr process.

Dr. Parr stresses the importance of accelerating the temperature rise of the coal from 100 deg. C. to the point where the pasty state is reached. This acceleration is aided by heat given up by the coal during the evolution of volatile gases. The values of the heat of reaction for seven varieties of coals has been determined by Davis, Place and Edeburn. These data are presented in the report in curve form.

Excerpts from a paper by William H. Allen, Jr., on "The Technical and Economical Aspects of Low Temperature Carbonization of Coal in Conjunction with Central Power Generation," are given in the report and indicate the anticipated benefits of carbonization to central power plants to be the reduction of steam fuel cost through credits derived from the sale of some of the products; an improvement in combustion efficiency; the elimination of smoke nuisance, and the elimination of reserve coal stocks which are subject to deterioration and spontaneous combustion. That the margin of profit obtainable by joint operation of power plant and coal carbonization may be small is shown in an assumed case which arrives at a gross profit of 2 cents per ton of dry coal. The gross profits are largely affected by the market value of the tar, an increase of one cent in the selling price increasing the gross profit by 30 cents.

Hydrogenation and Liquefaction of Coal and Oil

Extensive research work is reported in progress at several American laboratories on the hydrogenation and liquefaction of coal and oil. Some of this work has been kept confidential, while other laboratories have not as yet submitted statements.

Recent work both here and abroad has been largely based on catalytic processes similar to those developed by Dr. F. Fisher, also some success has been secured by the Bergius process.

Dr. Fisher has developed a low-pressure and low-temperature process to synthesize carbon monoxide and hydrogen into methanol. By selection of a proper catalyst mixture and by temperature regulation the process can be made to produce mainly casing-head gasoline or benzine. The theoretical yield of gasoline per 1,000 cu. ft. of gas is about 2 gal., and the indicated laboratory yield about 1 gal.

In the Bergius process coal ground to 2 millimeter size is mixed with pitch and ferric oxide in a closed retort. Hydrogen is pumped into the retort until the pressure reaches 100 atmospheres while cold; the temperature is then raised to 400 or 500 deg. C. This process yields, per 1,000 kg. of coal, 150 kg. of motor fuel; 200 kg. of Diesel oils; 60 kg. of lubricants; 80 kg. of fuel oils; 200 kg. of gas; 75 kg. of water; 5 kg. of ammonia; 130 kg. of pitch, and 100 kg. of ash.

Two plants are reported under construction in Germany, having a capacity of 1,000,000 bbl. of oil per year.

A. C. Fieldner, of the Bureau of Mines, reports considerable progress in identifying the constituents of low-temperature tar. The composition of the light oils obtained from the low-temperature carbonization of Utah coal has been determined by Brown and Cooper of the same bureau. Sixty-five per cent of the constituents of these oils were found to be olefins which impart a high degree of anti-knock properties to the light oils, making it a valuable material for blending with ordinary gasoline.

The Prime Movers Committee conclude their report with a bibliography of recent articles relating to the distillation products of coal.

Employee Serving Employer

By Leo T. Parker

A point of the law that has been given considerable attention by the recent higher courts is whether an employer is liable for injuries sustained by an employee who steps from his regular employment to perform a dangerous task in the interest of his employer.

Generally, an employer is not liable for injuries sustained by an employee where the latter is not acting within the scope of the employment.

However, in the case of Harlan Gas Coal Co. vs. Trail, 280 S. W. 954, decided within the last few weeks, a widow was held entitled to compensation for the death of her husband who was killed before he began the work for the day.

The facts of this case are that the workman had entered his employer's premises and was walking up a hill to his work when he observed a conductor of electricity lying on the ground. In attempting to remove it from the path, he was instantly killed.

The counsel for the employer contended that the workman had legally relinquished all rights to compensation when he attempted to remove the wire, as in doing so he assumed the risk of the act. And, further, that he should not have touched the dangerous wire, but should have notified the employer, who would have sent men competent and experienced in handling electrical apparatus to repair the break.

However, the court held the employer liable, and said:

"When he saw the electric wire lying across the path, he realized that its presence rendered the master's premises unsafe and subjected his fellow employees to great danger. The situation was such that, if he failed to take steps to remove the danger and death or injury resulted, the master would naturally feel aggrieved that he had not protected his interests. In attempting to meet the emergency and remove the danger, he was actuated solely by an impulse to serve his master and did only what an old and faithful employee would be expected to do in the circumstances. . . . There is the further contention that decedent's death was caused by willful misconduct. Willful misconduct is something more than ordinary or even gross negligence. It involves conduct of a quasi criminal nature, the intentional doing of something, either with knowledge that it is likely to result in serious injury or with a wanton and reckless disregard of its probable consequences."

In still another recent case, Young vs. Power Company, 191 Iowa 650, involving the same point of the law, it was disclosed that an engineer, whose duty was to operate the pumps of a power plant, was seriously injured when he attempted to repair other equipment over which he had no control, but which he observed needed immediate repairs.

This court, also, held the employer liable and in part said:

"Generally speaking, the employer of labor rightfully expects from his employee something of a spirit of loyalty and a reasonable degree of care for the protection of the employer's property in or about which his services are engaged. The hired servant is something more than a mere machine or automaton, and he brings to the service of the hirer, not merely a pair of hands, but hands plus brains and conscience, which will forbid an honest employee to stand idly by, refusing to interpose the slightest effort to save his employer from irreparable injury or loss, for no better reason than that the strict letter of his contract does not require such action on his part. Such terms are rarely, if ever, expressed in the words of the agreement between employer and employee; but it is at least what, for want of a better term, we may call a moral implication in every contract of hire, and the employee, no matter what may be his rank or station or what may be the prescribed limit or range of his ordinary duties, who discovers imminent peril or calamity threatening his employer in person or property, and without stopping to debate with himself whether he will respond to the emergent call upon his manhood, at once hastens to avert the damages as best he may, is not a mere intermeddler or volunteer, and the injury to which he thus exposes himself arises out of and in the course of his employment."

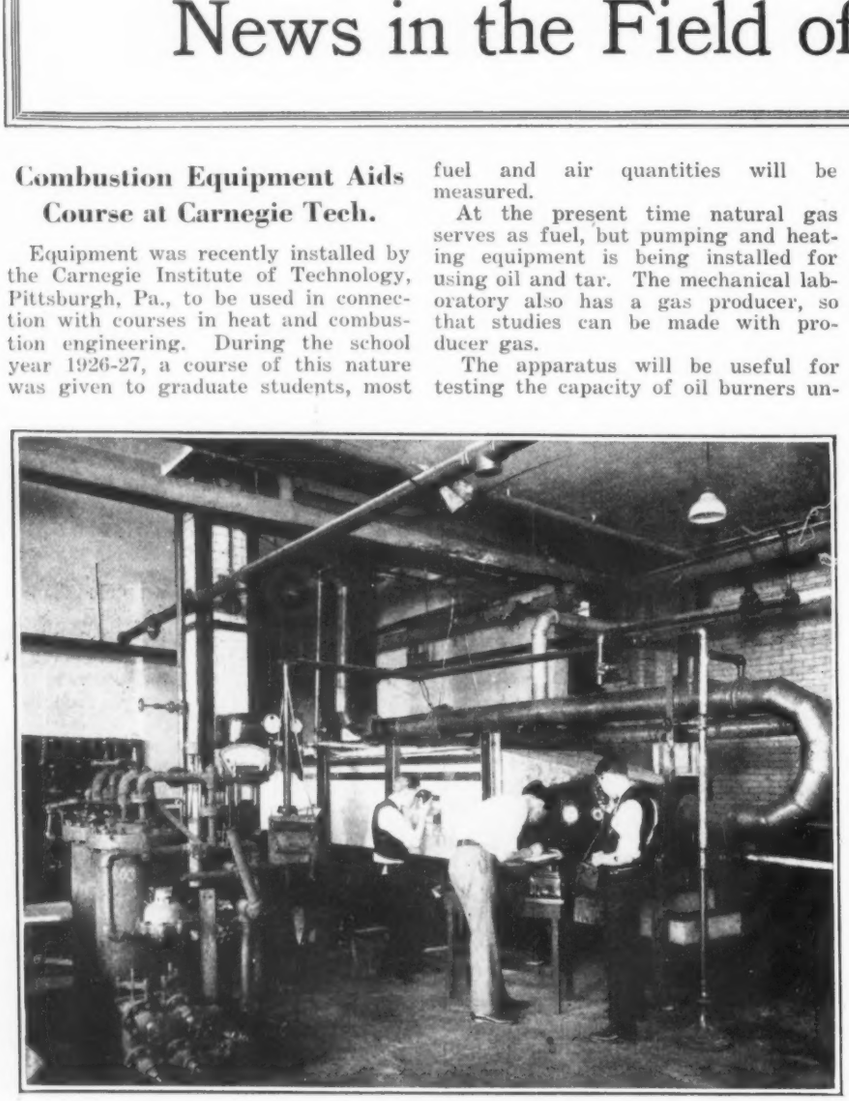
In still another recent case, London & E. S. Co. vs. Brown, 7 Sc. Sess. (5th Ser.) 488, the Lord Justice Clerk says: "I cannot doubt that in a sudden emergency, where there is danger, a workman does not go out of his employment if he endeavors to prevent the danger from taking effect."

The Verein deutscher Ingenieure organized in 1925 a committee known as the V.D.I. Speisewasserausschuss, or V.D.I. Committee on Feed Water. The first report of this committee has appeared in the research number of the *Zeitschrift* of the V.D.I. recently issued in honor of the birthday of Bach.

News in the Field of Power

Combustion Equipment Aids Course at Carnegie Tech.

Equipment was recently installed by the Carnegie Institute of Technology, Pittsburgh, Pa., to be used in connection with courses in heat and combustion engineering. During the school year 1926-27, a course of this nature was given to graduate students, most of them being combustion engineers of the Pittsburgh district. The equipment will be used from now on in the new day course in heat engineering, which is to be given in the mechanical engineering department by Prof. W. Trinks.



Newly installed combustion tunnel in one of the laboratories of the department of mechanical engineering, Carnegie Institute of Technology

The principal part of apparatus shown in the illustration consists of an oblong furnace to which various kinds of burners and combustion devices can be attached. Observation holes are provided through which flue-gas samples can be taken and through which the temperatures of the flame and of the furnace walls can be observed. Above the rear end of the tunnel there is a recuperator by means of which the combustion air can be preheated to about 800 deg. F. The piping and blast ducts are so arranged that the furnace can be supplied either with cold air or with hot air.

Instruments have been provided for measuring temperatures and for analyzing fuel as well as flue gases. All fuel and air quantities will be measured.

At the present time natural gas serves as fuel, but pumping and heating equipment is being installed for using oil and tar. The mechanical laboratory also has a gas producer, so that studies can be made with producer gas.

The apparatus will be useful for testing the capacity of oil burners under different conditions and for similar work, in addition to the combustion course for which it is primarily intended.

Mining in Nova Scotia in 1926

According to a circular issued by the Minerals Section of the Bureau of Foreign and Domestic Commerce the coal output of Nova Scotia for the year ended Sept. 30, 1926, was 5,652,314 tons, compared with the previous year's output of 3,288,321 tons. There was a four-month strike in 1925.

Shipments to the United States were 18,271 tons during the fiscal year, compared with 2,280 tons for the previous year. The quantity of tar manufactured from coal during the fiscal year was 6,634,031 imperial gallons, as against 2,973,108 gallons manufactured during the previous year. It is stated that the estimated coal resources of Nova Scotia (1915) were 2,188,151,000 actual reserve tons.

Seeks Development Permit for Potomac—Two Others

Development of water power on the Potomac River and its tributaries in the District of Columbia, in six counties in West Virginia, three counties in Maryland, and five counties in Virginia is proposed by the Potomac River Corporation, Wilmington, Del., in an application for a preliminary permit made to the Federal Power Commission on May 13, the Commission stated on that date.

Potomac River Corp., Wilmington, Del., requests a preliminary permit for a hydro-electric power project on the Potomac River and its tributaries in the District of Columbia, in Jefferson, Berkley, Morgan, Hempshire, Hardy, and Pendleton Counties, West Virginia, in Montgomery, Frederick and Washington Counties, Maryland, and in Fairfax, Loudoun, Clark, Warren and Rockingham Counties, Virginia.

Power is to be developed near Harpers Ferry, W. Va.; at Great Falls, near Washington, D. C., and at Chain Bridge, Washington, D. C. The four reservoirs are to store 1,650,000 acre ft. of water and are proposed to equalize the flow of the Potomac River to about 6,000 cu.ft. per second.

The power capacity of the project is not stated, but in Major Tyler's report the total combined installed capacity of the power plants at Great Falls and at Chain Bridge was recommended at 294,000 hp. The power to be generated is to be sold for public utility purposes to operating and distributing companies, to industries, and to other users of electric energy.

The Syndicate Power Co., of Dallas, Tex., has made declaration of its intention to construct a concrete dam across the Colorado River between Burnet and Llano Counties, Tex. The dam would be 180 ft. high with spillway.

The storage capacity of the reservoir, according to the Commission, would be 1,200,000 acre feet. The proposed installation is 40,000 hp. The project would be used for hydro-electric generation and for irrigation purposes.

The New Kanawha Power Co., Glen Ferris, W. Va., has applied for a preliminary permit for a project on Kanawha River in Fayette and Kanawha Counties, W. Va.

The project would develop the fall of 63 feet in three stages of 21 feet each, the initial installation at each of the three sites to be 8,000 horsepower, and the total ultimate installation to be about 65,000 horsepower.

The company plans to use the current for electrochemical and metallurgical uses and for public utility purposes. The construction would be carried on in connection with navigation improvements proposed on the river, the Commission stated.

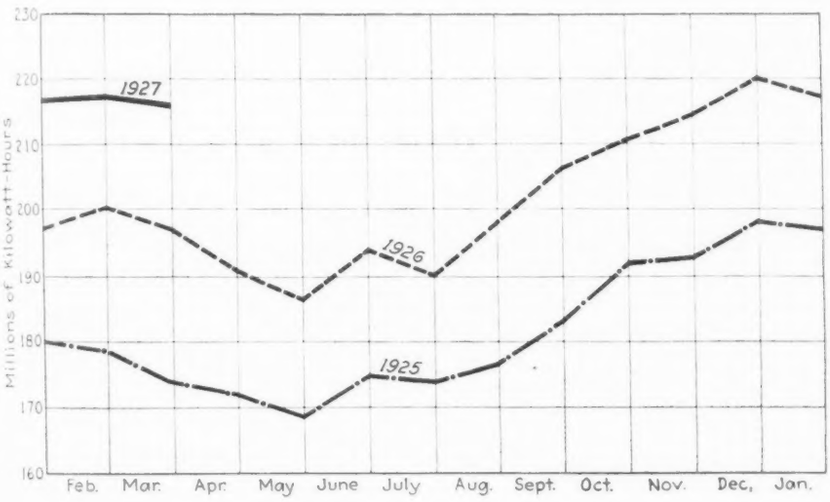
March Leads in 1927 Water Power Output —Records of 1926 Compared

Water Power Saved 2,500,000 Tons of Coal in March — Records of Plants Under 1,000 Kw. Are Not Included

ACCORDING to the report compiled by the Division of Power Resources of the Geological Survey, Department of the Interior, on the production of electrical power by public-utility plants in the United States, the average output in March was 216,000,000 kw.-hr. per day, or about half of 1 per cent less than the daily output for February.

More electricity was generated by the use of water power in March than in any previous month, the total amount being nearly 2.6 billion kilowatt-hours. The proportion of the total output produced by water power was about 38 per cent, which is not a record, as the output by the use of water power for some months has been over 40 per cent of the total. It would require more than 2,500,000 tons of coal to generate the kilowatt-hours produced by the use of water power in March.

The quantities given in the tables are based on the operation of all power plants producing 10,000 kw.-hr. or more per month, engaged in generating electricity for public use, including central stations and electric-railway plants. Reports are received from plants representing over 95 per cent of the total capacity. The output of plants that do not submit reports is estimated; therefore the figures of output and fuel consumption as reported in the accompanying tables are on a 100 per cent basis.



Output of Water Power Central Stations

Chicago A.S.M.E. Men Discuss Engineering Education

Developments in engineering education was the general topic of the Chicago Section of the American Society of Mechanical Engineers meeting for its final gathering of the season at the Hamilton Club May 11. According to custom, officers for the coming year were elected and the ladies of the Society participated in the entertainment.

Dr. Walter Dill Scott, president of Northwestern University, summarized the power development of various nations and attributed the success of this country to its unparalleled use of power, which he urged should be utilized for the advantages of the many and not restricted to the enrichment of a comparatively few individuals. Dean A. A. Potter of Purdue University, gave an able address on the subject of "Training in the Engineering College for Leadership in Industry." He favored a broader education for the engineer, a less number of studies but a more thorough mastery of each, and a greater number of schools with shorter and more intensive courses for training technical workers that would carry the student to the point reached at the end of the second year in college.

Results of the election were as follows: Thomas Wilson, Western Editor of *Power*, chairman; H. V. Coes, Belden Manufacturing Co., vice-chairman; Fred B. Orr, Illinois Maintenance Co., secretary-treasurer; past chairman, Hugo Diemer; R. H. Bacon, J. I. Banash, C. B. Cole and H. S. Dickerson, executive committee.

Coffin Fellowships Awarded to Five Students

Five graduate students have been awarded fellowships for the year 1927-28 by the Charles A. Coffin Foundation. These fellowships, which are awarded for one year, will enable the recipients to contine, or enter into, original research work at institutions of their own choosing. This makes a total of 39 graduate and undergraduate students who have held the fellowships

PRODUCTION OF ELECTRIC POWER BY PUBLIC-UTILITY POWER PLANTS IN THE UNITED STATES FOR JANUARY, FEBRUARY AND MARCH, 1927, IN THOUSANDS OF KILOWATT-HOURS

U. S. and Divisions	Water Power			Fuels			Total		
	January	February	March	January	February	March	January	February	March
United States	2,353,648	2,196,282	2,563,252	4,376,433	3,885,196	4,128,536	6,730,081	6,081,478	6,691,788
New England	165,769	155,223	175,832	330,817	286,866	294,636	496,586	442,089	470,468
Middle Atlantic	494,290	488,374	569,187	1,365,147	1,196,042	1,324,910	1,859,437	1,684,416	1,894,097
East North Central	174,423	182,642	227,581	1,463,360	1,301,183	1,401,947	1,637,783	1,483,825	1,629,528
West North Central	116,722	117,234	150,673	284,274	244,056	242,222	400,996	361,290	392,895
South Atlantic	230,322	207,645	265,720	463,373	434,288	446,001	693,695	641,933	711,721
East South Central	211,780	186,421	202,155	71,940	63,798	63,519	283,720	250,219	265,674
West South Central	6,695	7,463	7,486	249,625	231,702	243,771	256,320	239,165	251,257
Mountain	243,311	215,850	235,461	56,514	48,788	45,247	299,825	264,638	280,708
Pacific	710,336	635,430	729,157	91,383	78,473	66,283	801,719	713,903	195,440

PRODUCTION OF ELECTRIC POWER BY PUBLIC-UTILITY POWER PLANTS* IN THE UNITED STATES IN 1926

U. S. and Divisions	Total Power		Water Power			Fuel Power		
	Kilowatt-hours	Per Cent of U. S. Total	Kilowatt-hours	Per Cent of Total Power	Per Cent of U. S. Water Power	Kilowatt-hours	Per Cent of Total Power	Per Cent of U. S. Fuel Power
United States	73,791,064,000	100.00	26,188,801,000	35.5	100.00	47,602,263,000	64.5	100.00
New England	5,165,955,000	7.00	1,684,790,000	32.6	6.43	3,481,165,000	67.4	7.31
Middle Atlantic	20,526,802,000	27.82	6,049,534,000	29.5	23.10	14,477,268,000	70.5	30.41
East North Central	17,663,578,000	23.94	2,068,978,000	11.7	7.90	15,594,600,000	88.3	32.76
West North Central	4,586,814,000	6.22	1,515,433,000	33.0	5.78	3,071,381,000	67.0	6.45
South Atlantic	7,197,294,000	9.75	2,086,872,000	29.0	7.97	5,110,422,000	71.0	10.75
East South Central	3,049,199,000	4.13	1,925,679,000	63.2	7.35	1,123,520,000	36.8	2.36
West South Central	2,639,520,000	3.58	48,876,0000	1.9	.19	2,590,644,000	98.1	5.44
Mountain	3,424,715,000	4.64	2,833,527,00	82.7	10.83	591,188,000	17.3	1.24
Pacific	9,537,187,000	12.92	7,975,112,000	83.6	30.45	1,562,075,000	16.4	3.28

since the establishment of the Foundation in 1922.

The recipients are Carl D. Anderson, California Institute of Technology, for research at that university on the photo-electric properties of nickel; Kenneth T. Bainbridge, for research at the graduate school of Princeton University on photo-electric phenomena, using automatic films of alkali metals for the cathode surface; Charles S. Barrett for research at the University of Chicago, on the technique of measuring low X-ray intensities; James R. Harrison for research at Wesleyan University on the flexural vibrations in piezo-electric quartz crystals, and James B. Sharp, Jr., for research at Stanford University, on the properties of high-voltage insulation.

More Bids Required for South River Plant

Bids for a 1,150- to 1,250-hp. Diesel generating set for the municipal power plant of the Borough of South River, N. J., were opened April 18. The plant at present contains one 500-hp. unit and one of 750-hp. The rapid expansion of the industrial load compels, therefore, a considerable increase in the capacity of the plant.

The six bids offered appear in the tabulation. One outstanding point is the small differences in the three high bids when computed on the horsepower basis. The specifications called for the complete unit, including engine, generator, direct connected exciter and switchboard panel. The engine builder was to deliver and erect the machine on foundations supplied by the city. In addition, he was also to supply and install exhaust line and muffler, connections to the present water cooling and oil lines at the boundary wall, run necessary conduits between generator and switchboard, supply all small piping as well as the lubricating tank and lines. The foundation and building addition contract was let for the sum of $21,112.

After much study and examination of engines in other power plants the city authorities decided to reject all bids and readvertise, with a limitation on the r.p.m. of the offered units as well as a stipulation that engines similar to those offered must have been in successful operation for a period of at least two years.

It would appear that, if the cost of necessary accessories already in the plant were added to the quoted engine prices, the cost would total approximately $100 per hp., or $140 per kilowatt-hour.

Three-Unit Hydro-Electric Plant Controlled Automatically

Recently, a contract was placed with the Westinghouse Electric & Manufacturing Co. by the Kentucky Hydro-Electric Co. covering the complete automatic-switching and supervisory control equipment for their Kentucky River station at Dam No. 7. This equipment will control three 850-kva. 2,300-volt, vertical waterwheel generators, supplying a 33,000-volt three-phase transmission line. The generating units will be so arranged that each can be started or stopped separately, by float switches, time switches or supervisory control. The automatic synchronizing method will be used to bring each unit up to speed and check the phase relation before closing the generator breaker.

The supervisory control will be of the audible type with the control point situated at Dix River station. Indication at the Dix River station will be provided by a bell-and-buzzer system. A certain number of bell taps indicating headwater elevation, and changes in buzzer tone, the open or closed position of breakers, according to a prearranged schedule. A special feature, incorporated in the control, provides the dispatcher with a speed-checking device on either unit at any moment. To eliminate any possibility of two machines dropping their load at the same time, special interlocking devices will be provided between the generating units.

Dam No. 7 station will be the first automatic hydro-electric plant to be put in operation along the Kentucky River. Tentative plans, however, for the future expansion of the system provide for a chain of such stations to be built at various points on this river.

Principles of Boiler-Scale Formation and Prevention

A physico-chemical study of boiler-scale formation and boiler-water conditioning has been completed by chemists of the United States Bureau of Mines, Department of Commerce, in co-operation with Carnegie Institute of Technology and industrial interests. This is the first fundamental scientific study conducted, from the viewpoint of the physical chemist, of the mechanism of scale formation and corrosion under the temperature, pressure and concentration conditions that prevail in steam boilers.

The study has yielded fundamental data on which to prescribe a rational chemical treatment of boiler water, information which has been lacking in the past. The results of the investigation should tend to promote real conservation of fuels and boiler equipment and therefore offer an opportunity of effecting considerable savings in the nation's fuel bill. Fuel losses due to the formation of boiler scale run into enormous figures.

Erie Section To Hold Big Power Meeting

A big power meeting with the Erie (Pa.) Section of the A.S.M.E. as host will be held on June 3-4, 1927, and it has been promised that it will be one of the best summer technical meetings that has been held, as it will have the co-operation of the Power Division. The following papers are to be presented at the meeting:

"Modernization of Industrial Power Plants," by Major Clarence G. Spencer; "Conditions and Effects of Electric Drive as Compared with Older Methods," by R. H. Rogers; and "Some Fundamental Considerations in the Design of Boiler Furnaces," by Prof. W. J. Wohlenberg and F. W. Brooks.

Friday afternoon, June 3, will be given over to inspection trips through the large industrial plants of Erie, including those manufacturing writing paper, boilers, engines, power-plant equipment, mechanical rubber goods, electric motors, transformers and electric locomotives.

Draftsman Examination by the Civil Service Announced

The United States Civil Service announces that applications for mechanical draftsman and senior mechanical draftsman must be on file with the Civil Service Commission at Washington, D. C., not later than June 21. The examinations are to fill vacancies in the Departmental Service, Washington, D. C., and in positions requiring similar qualifications.

The entrance salaries in the Departmental Service are $1,680 and $1,850. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness and the occurrence of vacancies in higher positions. For appointment outside of Washington, D. C., the salaries will be approximately the same.

DIESEL ENGINE BIDS—SOUTH RIVER, N. J.

Bidders	Busch-Sulzer	Nordberg	Fulton Iron Works Co.		McIntosh-Seymour Co.	De La Vergne
			No. 1	No. 2		
Size engine (b.h.p.)	1,250	1,250	1,150	1,250	1,125	1,125
No. of cylinders	6	5	6	6	10	6
Bore and stroke, in.	17x27	20¾x26	23x29½	23x26	17x24	22x30
Cycles	2	2	4	4	4	4
R.p.m.	200	180	164	200	225	180
Piston speed, ft. per min.	900	780	806.3	866.6	900	900
M.e.p., lb. per sq.in.	67.3	62.5	75.5	76.2	72.6	72.4
Net weight, engine and flywheel, lb.	240,000	360,000	363,700	263,700	256,000	259,000
Generator, capacity	1,093	1,062	1,000	1,090	988	937½
Price erected	$96,850	$96,114	$88,425	$76,750	$75,000	$74,972
Price per b.h.p.	77.48	76.8912	76.8913	61.40	66.67	66.64

Power House Building Bids:—Casper Broger, $22,740; Fallon & Johnson*, $21,112; William Wright, $25,000.

*Awarded contract.

Osage River Development Shows Life

Interest in the proposed hydro-electric power plant on the Osage River near Bagnell, Mo., has been revived as a result of an application filed with the Missouri Public Service Commission at Jefferson City, Mo., on May 16 by the Missouri Hydro-Electric Co. for authority to issue 500 shares of non-par value common stock and also a note issue of $75,000 at 6 per cent to secure a loan.

Engineers Honored at West Point Visit

That engineers have a special interest in the United States Military Academy was indicated by a large delegation from the membership of the American Society of Mechanical Engineers, accompanied by representatives of several other engineering societies, who visited West Point May 12.

The Academy sprang from a school for engineers established at West Point during the Revolution. Twenty-two of its thirty-five superintendents have been engineers. As pointed out by Gen. M. B. Stewart, the present superintendent, engineering in most of its branches had its root in military operations. The Academy gave the first engineering instruction in this country, and for half a century it provided the country with most of its engineering skill.

Importance was attached to the visit of the engineers; the main feature was the regimental parade, in which the entire corps participated.

Because of lack of time, Charles L. Schwab, president of the Society of Mechanical Engineers, merely sketched the speech he had intended to deliver to the Cadet Corps.

Boiler Production Falls Off 15.3 Per Cent of 1926

That during April the boiler manufacturing industry continued its general downward trend in production, which started in January, is indicated by reports received by *Power* on the consumption of electrical energy by these manufacturing plants during that month. Indications are that the actual April production was about 15.3 per cent under April of last year and about 7.7 per cent under the preceding March production. However, corrections for number of working days in March and April establish the fact that the productive activity during April was only about 3 per cent under that recorded during March. The rate of boiler productive activity during April, however, was about 21.5 per cent under the rate of activity reported by these same manufacturing plants for last December.

That this general downward trend in boiler production will continue much longer is not borne out by contributing factors in general industry and general construction. The productive activity in general industry of the nation during the first quarter of the year was only slightly below that of the same period last year. Last month, April, the general production of the nation took a radical upward turn, productive activities during April being the highest ever recorded by American industry, being some 5 per cent above April last year and 2.5 per cent over the previous record productive activities reported in March, 1926. Also, the volume of construction contracts let during the first four months of the year, $877,271,000, is only about four million dollars under the record construction figures witnessed during the same period of last year.

Gets Medal for Daring Live Steam

Among those awarded medals by the United Gas Improvement Co. at a meeting of its associated companies gathered in the auditorium of the Central Y.M.C.A. for the opening of the 1927 conference on management, engineering and construction, the exceptional bravery of Foster Corn, night watchman of the Nashville Gas & Heating Co., Nashville, Tenn., was duly honored.

Foster, according to record, maintained uninterrupted gas service to Nashville by plunging through live steam in order to put a spare boiler feed pump into action when the active pump failed to function.

Duke-Price Power Plant Ready Soon

Announcement is made that within a short time the Duke-Price Power Co. will install the last two generators in its plant at Isle Maligne, Quebec.

At present there are in operation at the plant ten generator units, with a total capacity of 400,000 hp. The work of installing transformers and other equipment at the Isle Maligne plant, in connection with the transmission of 100,000 hp. to the plants of the Shawinigan Water & Power Co., at Quebec is practically completed.

The load carried by the Duke-Price plant has steadily increased during the last year owing to the operations of Price Brothers, the Aluminum Co., and the Port Alfred Pulp & Paper Mills. All work, such as dams and spillways, subsidiary to the Duke-Price plant, were completed at the beginning of this year.

Power Mergers Sought in Pennsylvania

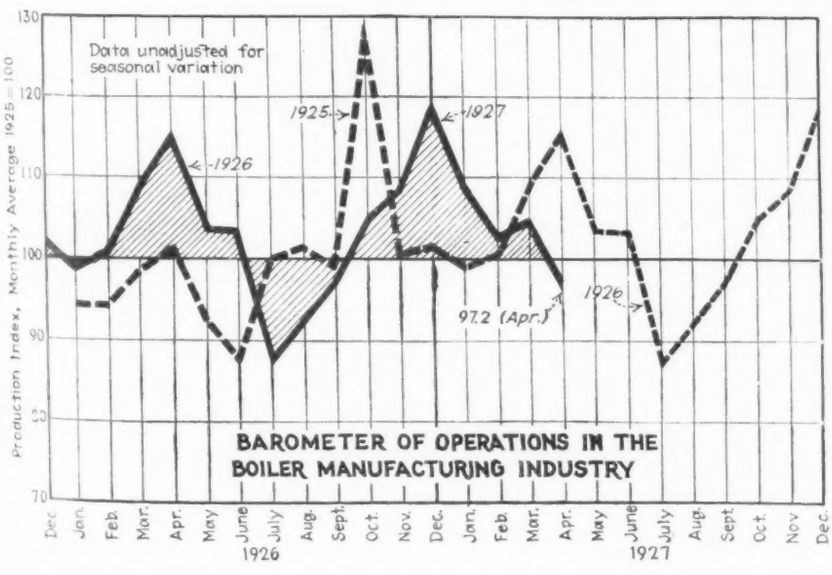
That a number of small mergers by eighteen power firms will be considered by the Public Service Commission of Pennsylvania, has been announced.

The Metropolitan Edison Co. seeks to acquire eight smaller firms in Lebanon, York, Cumberland and Adams Counties. The Northern Pennsylvania Power Co. seeks the acquisition of six companies in Bradford, Tioga and Wayne Counties. Two firms in Northumberland County are desired by the Pennsylvania Power & Light Co. The Riegelsville-Bucks Light & Power Co. is wanted by the Pennsylvania Edison Co., and the Boyertown Electric Co. has signified its intentions of absorbing the Bechtelsville-Berks Light & Power Co. in Berks County.

French Vote Power Plant on New Canal Stage

The French Chamber of Deputies recently passed a law granting a concession for the construction of a power plant to be erected on the first stage of the canal between Basle, Switzerland, and Strasbourg, France, according to Consul John D. Johnson, Strasbourg.

This action carries the approval of the construction of a canal between Basle and a point below Kembs, also the construction of a barrage on the River Rhine.



Personal Mention

Thomas Wilson, Western editor of *Power*, was elected chairman of the Chicago Section of the American Society of Mechanical Engineers at its meeting May 11.

Henry W. DeSaussure, Jacksonville, Fla., and **A. D. Buzby**, New York City, consulting engineers, announce the formation of the firm of De Saussure & Buzby, Inc., to engage in the general practice of engineering with principal offices in the Florida Theater Building, Jacksonville.

Business Notes

The R. H. Beaumont Co. and the Beaumont Manufacturing Co. have announced that E. A. Thurnlert is now associated with those organizations.

The Monson Maine Slate Co., Boston, Mass., producers of genuine Monson slate, announce the removal of their executive and sales office from 112 Water St., Boston, to new quarters at 38 Chauncey St., Boston, Mass.

The Bridgeport Brass Co. reports that Robert T. Kent, until recently superintendent of Prison Industries, State of New York, has been appointed to the position of general manager of the Bridgeport Brass Co., Bridgeport, Conn.

The Standard Fuel Engineering Co., 667-687 Post Ave., Detroit, Mich., recently appointed as selling agents for gas- and oil-fired furnaces and accessories in the New England States the Heat Treating Equipment Co., 79 Milk St., Boston, Mass. G. C. Davis is proprietor of the company.

The Detroit Stoker Co., Detroit, Mich., with works at Monroe, Mich., announces the removal of offices from 2 Rector St., New York City to 1729 Architects Bldg., 101 Park Ave., New York City, and from 702 Bellevue Court Bldg., 1418 Walnut St., Philadelphia, Pa. to 711 Peoples Bank Bldg., 20 South Fifteenth St., Philadelphia, Pa.

The Warren Steam Pump Co., Inc., is now represented by the Midwest Machinery Co., 4064 Olive St., St. Louis, Mo.; Ed. Trammell Pump & Machinery Co., 1112 West Twenty-fourth St., Oklahoma City, Okla., and the H. W. Pring Co., 3205 Commerce St., Dallas, Tex.

The Austin Co., engineers and builders, whose national headquarters are located in Cleveland, Ohio, has opened a branch office in Cincinnati. H. L. Cornelison, until recently manager of the Miami office, has been placed in charge of the new office located in the Dixie Terminal Building. Territory covered includes southern Ohio, southern Indiana and Kentucky.

The Bailey Meter Co., Cleveland, Ohio, announces the appointment of E. W. Fitch as manager of its St. Louis Office, 1808 Railway Exchange Bldg. Mr. Fitch, formerly engaged in field work in connection with Bailey combustion control equipment in the New England States, will now have charge of the sales and service work for the company in the vicinity of St. Louis, Mo.

The Climax Engineering Co., Clinton, Iowa, has added to its sales organization. H. P. McCullough who will be located at Houston, Tex., with offices at 328 Chronicle Building, and E. H. Crippen who will make his headquarters in Forth Worth, Tex., at 4023 W. 7th Street. Mr. McCullough and Mr. Crippen are both experienced in the oil field practice. The National Supply Companies are exclusive oil field distributors of Climax engines and the new members of the Climax sales force will work with them in the distribution of Climax products.

Reading Iron Co., Reading, Pa., has appointed Jack H. Beall to the sales force of the Chicago office, 449 Conway Bldg.

Coming Conventions

American Association of Engineers. Annual convention, Tulsa, Okla., June 6-8; M. E. McIver, 63 East Adams St., Chicago.

American Boiler Manufacturers Association. Annual meeting at French Lick Springs Hotel, French Lick, Ind., May 30-June 1.

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Pittsfield, Mass., regional meeting May 25-27. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Order of Steam Engineers. Annual convention, Moose Hall, 1314 North Broad St., Philadelphia, Pa. June 13-16; J. E. Burke, 1821 So. Ringgold St., Philadelphia.

American Society of Civil Engineers. George T. Seabury, secretary, 33 West 39th St., New York City. Annual convention at Denver, Col., July 13-15.

American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va., May 23-26. Calvin W. Rice, secretary, 33 West 39th St., New York City.

American Society of Refrigerating Engineers. Western meeting at White Sulphur Springs, W. Va., May 23-25, in conjunction with the Spring meeting of the A.S.M.E.; W. H. Ross, 35 West 39th St., New York City.

American Society for Testing Materials. Annual convention at French Lick Springs Hotel, French Lick, Ind., June 20-24; J. K. Rittenhouse, secretary, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. W. M. Niesley, assistant secretary, 170 Broadway, N. Y. Annual convention Hotel Sherman, Chicago, June 6-11.

Association of Iron and Steel Electrical Engineers. Annual convention at Pittsburgh, Pa., June 13-18, inclusive.

National Association of Practical Refrigerating Engineers. Annual convention probably in November; E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27; John Topman, secretary, convention committee, Ohio State annual convention in Memorial Hall, Lima, Ohio, June 16-18; P. H. Grigsby, secretary, Lima, Ohio. New England States convention at Portland, Me., June 17-18; Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass., Hartford meeting June 24-25, business sessions Saturday morning, aviation flight and banquet. Indiana State convention and power show at Anderson, May 27-28. Plainfield, N. J., meeting at Academy Hall, June 3-5.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., June 14-16 inclusive.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Convention at Atlantic City, June 6-10; exhibition, June 4-10.

Universal Craftsmen Council of Engineers. Thomas H. Jones, secretary, 33 Linden Ave., Cherrydale, Va. Annual convention at Buffalo, N. Y. Aug. 2-6.

The Homestead Valve Manufacturing Co., Homestead, Pa., announces the appointment of William F. Wilcox, sales engineer, 1205 Fourth National Bank Building, Atlanta, Ga., as the exclusive agent in the city of Atlanta and surrounding territory. Mr. Wilcox will handle the complete list of Homestead quarter-turn valves, Hovalco-Homestead blowoff valves, and also the protected seat hydraulic operating valve manufactured by this company, and is prepared to make prompt shipment and give the engineering service necessary.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 16 1927
Pool 1	New York	$2.50@$3.00
Smokeless	Boston	1.70
Clearfield	Boston	1.60@ 1.85
Somerset	Boston	1.75@ 2.00
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.75@ 2.00
Pittsburgh	Pittsburgh	2.00@ 2.20
Pittsburgh gas slack	Pittsburgh	1.45@ 1.60
Franklin, Ill.	Chicago	
Central, Ill.	Chicago	
Ind. 4th Vein	Chicago	
West Ky.	Louisville	1.50@ 1.75
S. E. Ky.	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.50@ 1.90
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.50@ 3.00
Buckwheat No. 1	Philadelphia	2.50@ 3.00
Birdseye	New York	1.40@ 1.60

FUEL OIL

New York—May 19, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 5¾c. per gal. f.o.b. Bayonne, N. J.

St. Louis—May 12, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.60 per bbl.; 26@28 deg., $1.65 per bbl.; 28@30 deg., $1.70 per bbl.; 30@32 deg., $1.75 per bbl.; 32@36 deg., gas oil, 4.73c. per gal.; 38@40 deg., 5.23c. per gal.

Pittsburgh—May 9, f.o.b. local refinery; 30@34 deg., fuel oil, 6c. per gal.; 36@40 deg., fuel oil, 6.25c. per gal.

Philadelphia — May 13, 27@30 deg., $2.25@$2.31 per bbl.; 13@19 deg., $1.75 @$1.81 per bbl.

Cincinnati — May 16, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—May 10, tan-car lots, f.o.b. Okahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.00 per bbl.; 26@30 deg., $1.05; 30@32 deg., $1.10.

Boston—May 16, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.3c. per gal.; 28@ 32 deg., 5.8c. per gal.

Dallas—May 14, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

The **Gas Products Association**, 140 South Dearborn St., Chicago, composed of manufacturers of oxygen, acetylene, hydrogen, welding and cutting apparatus, accessories, supplies, etc., located throughout the United States, have recently completed two reels of welding and cutting films. A limited number of prints of these films are available to organizations desiring to show them before audiences by making application to the association secretary.

The Combustion Engineering Corp. has appointed William B. Senseman as Pacific Coast district manager for Raymond Bros. Impact Pulverizer Co., Ladd Water Tube Boiler Co. and Heine Boiler Co., all subsidiaries of International Combustion Engineering Corp. Mr. Senseman has been associated with Raymond Bros. Impact Pulverizer Co. for the last 15 years and since 1917 has represented that organization on the Coast. The new consolidated offices are located in the Subway Terminal Building, 417 South Hill St., Los Angeles, Calif.

Edward C. Dingman, Montreal dealer of the Climax Engineering Co., Clinton, Iowa, has moved his office from the Keefer Building to 1120 Castle Bldg., 1410 Stanley St., Montreal. Mr. Dingman handles the sale of Climax engines in Quebec and the eastern provinces.

Trade Catalogs

Diesel Engines—The Chicago Pneumatic Tool Co., Chicago Pneumatic Building, 6 East 44th St., New York City, has just published Bulletin 774 which covers the type RH 40 Benz Diesel engine, in horsepowers from 80 to 240 at 327 r.p.m. Following a general description details of construction are given. The whole is illustrated throughout.

Constant Voltage During Variable Loads—The American Brown Boveri Electric Corp., 162 Broadway, New York City, announces that circular No. D.M. 7001, "Constant Voltage—during variable Loads" is available for distribution. This 4-page pamphlet deals with the advantages attendant upon the use of the A.B.B. quick-acting, automatic voltage regulator. The circular is well illustrated with halftones and line cuts.

Price List of Protective Coatings—The Dampney Company of America, manufacturer of protective coatings for metal surfaces, Hyde Park, Boston, Mass., has issued price lists covering Apexids Nos. 1 and 3, for hot-wet metal surfaces and for cold-wet or hot-dry metal surfaces respectively.

Floor Grating—The Hendrick Manufacturing Co., 60 Dundaff St., Carbondale, Pa., has issued a bulletin on Mitco interlocked steel grating, made of high-tensile square-edge steel bars, permanently locked in position. Ninety per cent open area is afforded, providing maximum light and ventilation. This grating is furnished in units of various types and depths to meet every need for plant and industrial flooring and footway.

Descriptive of American Brown Boveri Plant—The American Brown Boveri Electric Corp., 165 Broadway, New York City, announces that circular No. D.M. 10,000 is available for distribution. This 16-page illustrated publication describes the American Brown Boveri Electric Corp., Camden, N. J., plant, organization and products, particular emphasis being placed on its most recent achievements, in the power, railroad, railway, dredge, harbor, marine and industrial fields.

New Plant Construction

Calif., Los Angeles—Childrens' Hospital Assn. awarded contract for the construction of a hospital and nurses' home at Sunset Blvd. and Vermont Ave., to Wurster Construction Co., 1205 National City Bank Bldg. Estimated cost $491,967. Steam heating system, elevators, etc. will be installed.

Calif., Los Angeles—H. C. Jensen, 1728 Westmoreland Ave., is having plans prepared for the construction of a 4 story apartment building including steam heating and ventilation systems, etc. at Holly St. and Raymond Ave. Estimated cost $500,000. Elimar E. B. Meinardus, 311 South Vermont Ave., is architect.

Calif., Sacramento—Consumers Ice & Cold Storage Co., 9th and C Sts., plans the construction of an addition to cold storage plant at 8th and D Sts. Estimated cost $125,000. H. L. Lincoln, 354 Pine St., San Francisco, is engineer.

Calif., San Diego—Munday & Black, et al c/o L. A. Smith, Film Exchange Bldg., Los Angeles, Archt., are receiving bids for the construction of a 12 story office building at B, C, 4th and 5th Sts. Estimated cost $750,000.

Calif., Watsonville—Growers' Cold Storage Co., c/o Austin Co. of California, 244 Kearney St., San Francisco, Engr., is having plans prepared for the construction of a cold storage plant here. Estimated cost $200,000.

D. C., Washington—March & Peter, 1302 F St., N. W., and A. B. Mullett & Co., Union Trust Bldg., 15th and H Sts. N.W., Assoc. Archts. will soon receive bids for the construction of a 9 story bank and office building including vapor heating system, electric elevator, etc. at 1502-1504 H. St. N.W., for Union Trust Co. Estimated cost $500,000.

Ga., Macon—Greater Wesleyan College, will soon receive bids for the construction of a college and heating plant. Estimated cost $500,000. Walker & Weeks, 1900 Euclid Ave., Cleveland, O., are architects. Finwoody and Oliphant, 490 Broadway, Macon, Ga., are associate architects.

Ill., Chicago—Cheatnut Building Corp., c/o Rissman & Hirschfeld, 54 West Randolph St., Archts., will soon award contract for the construction of a 17 story apartment building including mechanical refrigeration and ventilation systems, elevators, etc., at Chestnut and De Witt Sts., for Chestnut Building Corp., c/o Archts. Estimate cost $3,250,000.

Ill., Hartford—International Shoe Co., 1505 Washington Ave., St. Louis, Mo., is having plans prepared for the construction of a boiler house here. Estimated cost $40,000. H. Reinhardt, 1820 Cherokee St., St. Louis, Mo., is architect. F. Hume, 1820 Cherokee St., St. Louis, Mo., is engineer.

Kan., Argentine—Chicago, Rock Island & Pacific Ry. Co., La Salle St. Station, Chicago, Ill., is having plans prepared for the construction of an ice plant, here. Estimated cost $250,000. C. A. Morse, is chief engineer.

Mass., South Boston (Boston P. O.)—New York, New Haven & Hartford R.R. Co., New Haven, Conn., awarded contract for the construction of a power plant here, to H. B. Kents, 5 Erie Ave., Rutherford, N. J. E. Gagel, is chief engineer.

Minnesota—Northern States Power Co., R. F. Pack, V. Pres. and Gen. Mgr., 15 South 5th St., Minneapolis, plans the construction of two power plants and dams, 106,000 hp. capacity on the Mississippi River near Monticello and Otsego, Minn., also one at Nevers, Wis., on the St. Croix River, 28,000 hp. capacity, and one at Kettle Falls, Wis., on the St. Croix River, 38,000 hp. capacity. Estimated cost approximately, $10,000,000, $5,000,000 and $5,000,000 respectively. Private plans.

Minn., Duluth—Minnesota Power & Light Co., 30 West Superior St., Duluth, has authorized $1,250,000 for construction to be carried through this year, plans include transformer units, transmission lines, generator at Little Falls, etc. Work by day labor under the supervision of L. M. Pharis, Engr.

Miss., Natchez—Natchez Hotel Co., c/o Eagle & Laub, will soon receive bids for the construction of a 5 story hotel including steam heating system, etc. Estimated cost $500,000. Weiss, Dreyfous & Seiferth, Maison Blanche Bldg., New Orleans, La., are architects.

Mo., St. Louis—Bd. of Public Service, 208 City Hall, will receive bids until June 21 for the construction of a 24 story civil courts building including steam heating system, elevators, etc. at 11th, Market, Chestnut Sts. and Municipal Plaza. Estimated cost $2,750,000. Plaza Commission Inc., c/o owner, is architect and engineer.

Mo., St. Louis—A. E. Lewis, c/o Sylvester Lewis Realty Co., 4919 Natural Bridge Ave., will build an 8 story hotel at Natural Bridge and Spring Aves. Estimated cost $750,000. J. T. Craven Engineering Co., Century Bldg., is architect and engineer. Work will be done by separate contracts. Steam heating system will be installed.

Neb., Grand Island—City awarded contract for the construction of addition to power plant including two 700 hp. superheaters, two closed feed water heaters, one centrifugal pump, two storage tanks, etc. to Ernest Rokahr & Sons Construction Co., 915 Terminal Bldg., Lincoln. Estimated cost $65,000.

N. J., Elizabeth—Elizabeth Chamber of Commerce Hotel Co., 227 Broad St., will receive bids about June 1 for the construction of a 10 story hotel including steam heating and refrigeration systems, boilers, pumps, elevators, etc. Estimated cost $1,000,000. W. L. Stoddart, 50 East 41 St., New York, N. Y., is architect. H. B. Bardy, 333 North Broad St., Elizabeth, N. J., is associate architect.

N. J., Newark—L. Cahan, Bankers Trust Bldg., Philadelphia, Pa., is having sketches made for the construction of a 20 story hotel including steam heating and refrigeration systems, boilers, elevators, etc., here. Estimated cost $4,000,000. F. Grad, 1021 Broad St., Newark, N. J., is architect.

N. J., Newark—Presbyterian Hospital, 25 South 9th St., is having preliminary plans prepared for the construction of a 6 story hospital including steam heating, refrigeration and ventilation systems, boilers, elevators, etc. Estimated cost $500,000. Sutton, Sutton & Calkins, 402 Broad St., are architects.

N. Y., Long Island City—National Sugar Refining Co., Front St., had plans prepared for the construction of a refinery and power plant. Estimated cost $1,000,000. Private plans.

N. Y., New York—Three Hundred Eighty Six Fourth Ave. Corp., c/o A. Greenbaum, 232 Madison Ave., will build a 20 story loft building. Estimated cost $1,250,000. Almirall & Cusachs, 14 East 46th St., are architects. Work will be done by separate contracts. Steam heating system, boilers, pumps, elevators, etc. will be installed.

N. Y., New York—Washington Square Apartments Inc., T. K. Garry, Pres., c/o T. W. Lamb, 644 8th Ave., Archt., is having plans prepared for the construction of a 16 story apartment building including steam heating and ventilation systems, boilers, pumps, elevators, etc. at 71-72 Washington Sq. South. Estimated cost $500,000.

N. Y., Plattsburg—Constructing Quartermaster, will soon award contract for the construction of a group of buildings including boiler house, etc. at Plattsburg Barracks.

O., Canton—Bd. of County Commissioners, will receive bids until June 2 for the construction of a group of hospital buildings including boiler house, etc. on Alliance Rd. Estimated cost $1,000,000. A. E. Thayer, New Castle, Pa., is architect.

O., Cincinnati—Christ Hospital, Auburn Ave., plans the construction of a 7 story hospital and nurses' home. Estimated cost $1,500,000. Tietig & Lee, 34 West 6th St., are architects.

O., Portsmouth—City, J. R. Lyon, Dir. of Service, is having sketches made for waterworks improvements including filtration plant, pumping station, reservoir, etc. Estimated cost $835,000. J. A. Hiller, 2451 Madison Rd. Hyde Park, Cincinnati, and C. H. Anderson, 2886 Ziegle Ave., Hyde Park, Cincinnati, are engineers.

Okla., Maud—Western Ice Co., Shawnee, had plans prepared for the construction of a 20 ton ice plant here. Estimated cost $40,000. Private plans.

Pa., Pittsburgh—J. I. Simon et al, 5th Ave., is having plans prepared for the construction of a 22 story hotel. Estimated cost $1,000,000. C. & C. J. Reiger, Citizens Bank Bldg., are architects.

Pa., Springles (Mills P. O.)—Phillips Gas & Oil Co., Butler, awarded contract for the construction of a compressor station here, to The Austin Co., Union Trust Bldg., Pittsburgh. Estimated cost $40,000.

Tex., Colorado — California Co., c/o Chamber of Commerce, has been granted permit for the construction of a pumping plant on North Elm Creek for mining purposes. Estimated cost $50,000. Private plans. Gasoline engines, etc., will probably be required.

Tex., Houston—San Jacinto Trust Co., Humble Bldg., is having plans prepared for the construction of a 22 story office building at Lamar and Main Sts. Estimated cost $1,250,000. A. C. Bossom, 680 5th Ave., New York, N. Y., is architect.

Tex., McAllen—Rio Grande Valley Cold Storage Co., will soon receive bids for the construction of a cold storage plant. Estimated cost $150,000. Private plans.

Tex., Panhandle—Kansas City Power & Light Co., 14th St. and Grand Ave., Kansas City, Mo., operating in Texas under Panhandle Light & Power Co.; Abilene, has been granted franchise to construct a power plant at Magic City, a new townsite near here. Estimated cost $90,000.

Tex., Taylor—E. Doak, plans the construction of a pumping plant for diversion of 500 acre ft. of water from San Gabriel River for irrigation purposes. Estimated cost $30,000. Private plans.

Vt., Castleton—State of Vermont, J. W. Weeks, Governor, is having preliminary plans prepared for the construction of a dormitory and heating plant at State Normal School. Estimated cost $150,000. A. H. Smith, Gryphon Bldg., Rutland, is architect.

Ont., Ottawa—Dept. of Public Works, plans the construction of a 6 or 8 story office building including steam heating system, etc. Estimated cost $3,000,000. R. C. Wright, Parliament Bldg., is architect.

Equipment Wanted

Air Compressor, etc.—Universal Equipment Co., Olathe, Kan., is in the market for a belt-driven air compressor with motor, air motor, cutting torch and other boiler tools, etc.

Air Compressor Unit—City of Cleveland, O., will receive bids until May 27 for one portable air compressor unit complete with tools.

Boiler and Stoker Equipment—L. Bever, Clk., Greenville, Ind., will receive bids until June 1 for boiler and stoker equipment for municipal electric light plant.

Boiler, Stoker and Generator Set—City of Blair, Neb., will receive bids until June 3 for a 250 hp. boiler and stoker complete, 300 kw. engine generator set, etc. for proposed addition to electric light and power plant. Estimated cost $35,000.

Boilers, etc. — Missouri - Kansas - Texas Lines, St. Louis, plans the installation of boilers and other miscellaneous equipment in power plant at Sedalia, Mo. Estimated cost $60,000.

Boilers and Stokers—Dept. of Welfare, J. E. Harper, Dir. Ninth and Oak Sts., Columbus, O., is in the market for four 250 hp. boilers and mechanical stokers for power plant at Longview State Hospital, Cincinnati, O.

Burner—W. J. Chamberlain, Broadway, Little Rock, Ark., is in the market for a crude oil burner for 6 and 8 hp. upright boiler, gravity feed or electric motor driven.

Compressor, Pump, etc.—City of Many, La., will receive bids until May 31, for a motor driven compressor, 500 g.p.m. motor driven fire pump, etc. for proposed waterworks improvements. Estimated cost $50,000.

Engines, Generators, Transformers, Switchboards, Etc.—G. L. Craddock, Clk., Lanigan, Sask, will receive bids until June 1, for internal combustion engines, generators, exciters, transformers, switchboards, etc. for proposed power station and cooling chamber.

Motors—Gnaedinger & Wilson, 75 St. Antonio St., Montreal, Que., is in the market for four 11½ hp. electric motors.

Pump—City Commissioners, J. M. Miller, Clk, Calgary, Alta., will receive bids until May 25 for a centrifugal pump.

Pump—City of Hollis, Okla., is in the market for a 250 g.p.m. motor driven centrifugal pump for waterworks.

Pump, Etc.—City of Martha, Okla., will be in the market for a pump, etc. for proposed waterworks and distribution system. Estimated cost $15,000.

Pump and Motor—City of Blackwell, Okla., is in the market for a 3,000 g.p.m. centrifugal pump and 250 hp. motor.

Pump and Motor—City of Terral, Okla., will be in the market for a new pump and motor for proposed waterworks improvements. Estimated cost $20,000.

Pump and Motor—E. W. Villines, Clk, Maud, Okla., will receive bids until June 7 for a deep well pump, and motor for proposed waterworks improvements. Estimated cost $15,000.

Pump and Motor, Etc.—City of Kingston, Okla., will be in the market for a pump and motor, etc. for proposed waterworks improvements. Estimated cost $30,000.

Pumping Equipment—City of St. Martinsville, La., will be in the market for pumping equipment, etc for proposed improvements to waterworks. Estimated cost $60,000.

Pumping Equipment—City of El Dorado, Okla., will be in the market for pumping equipment, etc. for proposed waterworks improvements. Estimated cost $110,000.

Pumping Equipment—Water & Light Comn., A. J. Warner, Supt. of Water, Moorhead, Minn., will soon receive bids for pumping equipment etc. for proposed waterworks improvements. Estimated cost $15,000.

Pumping Plant Equipment — Phillips Petroleum Co., Breckenridge, Tex., will be in the market for equipment for proposed pumping plant, probably electrically driven. Estimated cost $75,000.

Pumps, Motors, Etc.—G. H. Biles, Dir., City Hall, Philadelphia, Pa., will receive bids until June 8 for pumps, motors, etc. for proposed sewage disposal plant and pumping station.

Pumps and Motors—City of Tecumseh, Okla., will be in the market for two deep well pumps and motors for proposed waterworks system. Estimated cost $35,000.

Pumps and Pumping Equipment—City of Kewanee, Ill., will be in the market for deep well or air lift pumps, pumping equipment, etc., for proposed waterworks improvements.

Pumps and Pumping Equipment—City Commission, Birmingham, Ala., will receive bids until June 29 for pumps and pumping equipment, etc. for proposed sewage pumping station. Estimated cost $167,300.

Refrigeration Equipment—Dept. of Mental Hygiene, Capitol, Albany, N. Y., will receive bids until June 8, for refrigeration equipment for service and administration building, etc.

Switching and Control Equipment, Transformers, Etc.—Dept. of City Transit, Philadelphia, Pa., will receive bids until May 31 for switching and control equipment, auxiliary transformers, etc. for sub-stations 4, 5 and 6 for Broad St. subway.

Transformers—Utilities Commission, J. Stalker, Comr., Simcoe, Ont., plans the installation of additional transformers to increase the capacity of electric light plant. Estimated cost $25,000.

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